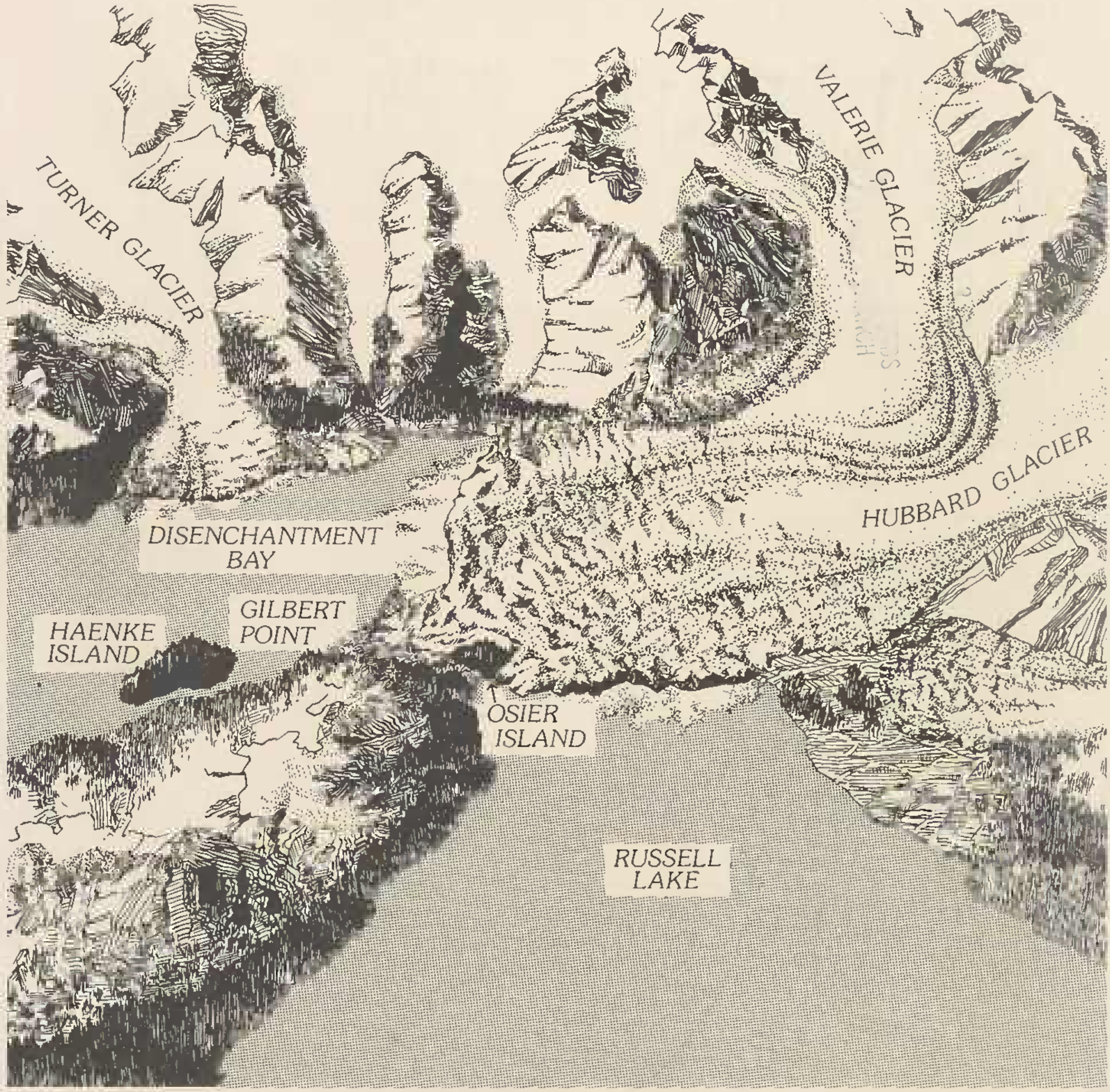
Situk River Flood Plain Analysis

Alaska
Region
R10-MB-30



SITUK RIVER FLOOD PLAIN ANALYSIS

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Juneau, Alaska
February 1988

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When Russell Fiord is again blocked off by the advance of Hubbard Glacier, the resulting "Russell Lake" will fill to overflow in a minimum of 7 and a maximum of 12-14 months. The overflow will have average flows of approximately 20,000 cfs, low flows of 900 cfs and maximum peaks flows of approximately 50,000 cfs. The overflow elevation for Russell Fiord is 131.1 ft at approximate mile post 0.5 in the "notch" section.

Russell Lake will attenuate inflow floods and produce overflow peaks into the Old Situk River that range between 24 and 34 percent of the flood peaks flowing into the lake.

The overflow will be confined to a well defined channel from mile post 0.3 (lake outlet) to mile post 5.5. From MP 5.5 to 13 the flow will follow fairly well defined historic meanders, braids and existing flow paths. The main flow path from MP 13 to the ocean (MP 17) will occupy the Lost River flood plain. Most historic channels have a new growth of vegetation since the last event approximately 150 years ago.

Initial flows will reach higher levels in the channel(s) than subsequent flows of equal magnitude due to the increased hydraulic friction caused by existing vegetation in the flow paths. The overflow will remove this vegetation by hydraulic erosion of the root systems to form debris dams and channel meanders. Eventually as the material is buried, sidecast, or carried out to the ocean the channel(s) will stabilize.

The established flow regimen will not impact the Yakatat airport unless debris damming causes a major shift in flow path from MP 13 to the ocean.

Projected flood plain limits for low (10,000 cfs) and high (50,000 cfs) flows are shown on fold out MAP C located in the map envelope.

Distances and elevations contained in this report are generally obtained by photogrammetric methods and are adequate for planning purposes. Any site specific details or plans for engineering works will require field surveys to establish vertical and/or horizontal control.

Decisions and/or actions of hydraulic interest for the immediate future are:

A. Field surveys are needed between mile post 13 and the Lost River to determine historic or future channels.

B. Investigation of a bridge crossing site at mile post 3.6 is needed if a decision is made to maintain road access past Alsek road mile 11.

C. An early decision regarding vegetation management in the main overflow channel is needed. If clearing is proposed, field surveys will be required to define the 10,000-20,000 cfs channel prism in the areas selected for clearing and to establish clearing limits in the field. The actual clearing could be accomplished during a three or four month construction operation after the lake starts to fill.

I. INTRODUCTION

A. Here come the flood. The continued advance of Hubbard glacier over the last 90 years finally produced a closure of Russell Fiord on 5/29/86. Runoff into Russell Lake (formed by the closure) increased the water level over 4 months to an elevation of 83 ft before the ice dam breached and drained the lake on 10/8/86. This temporary reprieve will be short lived as the glacier continues its' advance with closure approaching on a wider and more stable face. A lake level elevation of 131.1 ft will initiate flow into the historic overflow channels of the Old Situk and Situk Rivers. This overflow will change a recent (150 year) hydraulic system having average flows of 1200 cfs into a system with average flows of at least 17,000 cfs (based on the 4 month average established during the first closure). This flow will cause significant changes in existing fisheries, access, use and economy of the Situk drainage. Page 2 is a project area map. The river miles are scaled map locations only.

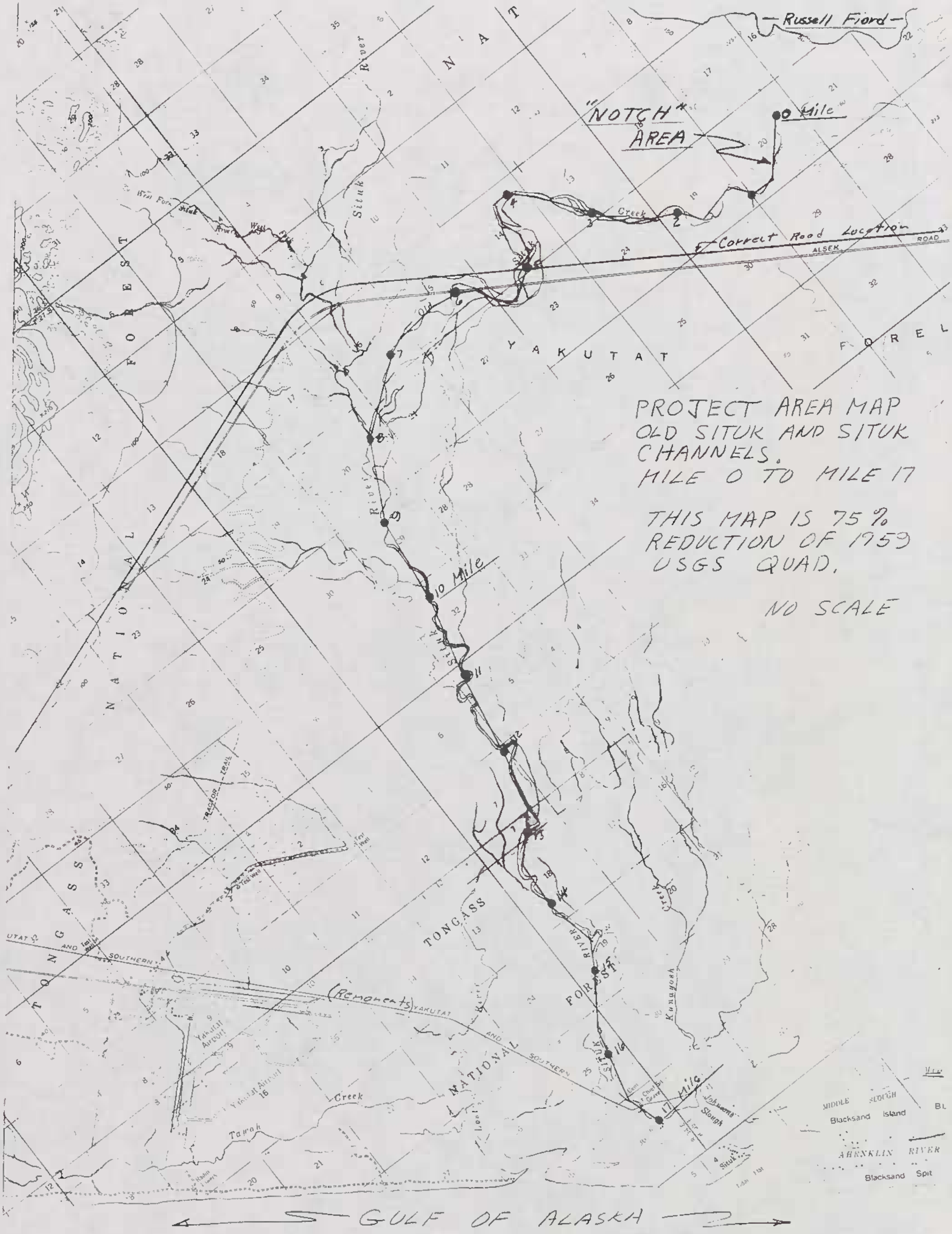
B. Requested assistance. As the initial closure approached, an interagency team chaired by the Chatham Area of Tongass NF was formed to coordinate various agency activities associated with the potential overflow. The Regional engineering office of the Forest Service was asked to provide a hydraulic analysis of the overflow system and to produce a report of the findings. This report completes our assignment.

C. Hydraulic analysis. Location of the new stream channel(s) and their volumes of flow are basic to the report. We have relied on the Chatham Area forest hydrologist for hydrology of the Russell Lake and Situk watersheds (Paustian 1988). Routing the inflow hydrograph thru Russell Lake and the Situk system was done by RO engineering. Questions about the airport area, vegetation in historic channels, continued road access past mile 11 on the Dangerous river road (Alsek road), and mitigation options surfaced during the process and are also addressed.

II. INVESTIGATION

A. Topographic maps. The existing (1959) USGS quad maps for Yakutat provide 50 ft contour information. This is not detailed enough for hydraulic analysis of the flood plain on a stream system that is 17 miles in length and has only 130 ft of elevation change. The interagency committee recommended and USGS agreed to prepare an updated topographic map of the area with detail to 5 meters (2.5 meters in selected areas) at a scale of 1:25,000. Ground photo control points were installed during September of 1986 using GPS equipment and the updated topographic map proofs were completed by USGS. Copies of this map may be obtained from the USGS at a later date.

Subsequent to this work, it was discovered that even the 2.5 meter contours exceeded the actual relief by a factor of 3. The Forest Service prepared and awarded a photo interpretation contract to identify and plot 26 cross


Russell Fiord
"NOTCH" AREA
0 Mile
Correct Road Location
ALSEK ROAD
YAKUTAT
PROJECT AREA MAP
OLD SITUK AND SITUK
CHANNELS.
MILE 0 TO MILE 17
THIS MAP IS 75%
REDUCTION OF 1959
USGS QUAD.
NO SCALE
10 Mile
Situk River
TONGASS NATIONAL FOREST
(Remnants) YAKUTAT AND SOUTHERN
17 Mile
Blacksand Island
AHRNKLIN RIVER
Blacksand Spit
GULF OF ALASKA

sections, selected stream profiles, and random elevations to an accuracy of 2 ft vertically. Tapes of the data are filed in RO Engineering.

B. Photos. The Yakutat area has the following aerial photo coverage.

Date	Scale	Type	Contractor
9/86	1:24,000	Color	N. Pacific Aerial Surveys
8/86	1:58,000	CIR	Keystone
8/86	1:80,000	B&W	Keystone
78-79-81	1:62,500	CIR	NASA
6/78	1:125,000	B&W	NASA
6/74	1:15,840	Color	??

An uncontrolled mosaic of the floodplain area using 9/86 1:24,000 color aerial photos was produced by the Forest Service and reproduced at 1:25,000 scale. Color prints of this 24" X 40" mosaic can be viewed at the Sitka, Juneau and Yakutat Forest Service offices. A black and white 1/2 tone print is included in the envelope section of this report. Copies of the color Mosaic can be purchased from RO Geometronics. The 1:25,000 scale mosaic costs $50. Reproduction at other scales is also possible.

Photos of typical channels in the Situk and Dangerous river areas are included on pages 8 and 9 of Appendix A.

C. Field visits and surveys. Paul, Powell and Rogers visited Yakutat on 8/20-21/86 to view the lake overflow area, vegetation in the existing flood plains and make preliminary classification of soil materials in the existing channels. The trip report is included as Appendix A.

Paul, Paustian and Wilson visited Yakutat on 6/18-20/87 to measure typical cross sections, investigate stream overflow channels in the lower Situk river, and look at the streams tributary to the Lost river. A trip report was not prepared.

Jim Landurm and crew performed a control survey to verify the "notch" elevation and establish a permanent cross section on 10/20-29/87. Portions of this surveyed data are included.

D. Miscellaneous. Paustian's flow measurements of the Dangerous river are included and were used to calculate a Mannings friction value "n" of 0.033 for wide channels in the Yakutat Foreland outwash materials. A photo of this typical channel is on page 8 of Appendix A.

Volume calculations of the Russell Fiord reservoir are included. These values are shown as volume(s) per inch (and tenths of foot) to allow calculation of daily inflow into the lake based on water level rises.

Average flows for the inflow into Russell Lake were calculated as 17,260 cfs for the 132 day period from May 29 to October 8, 1986. The mid-July to mid-August flows averaged 27,500 cfs. Based on this information we

arbitrarily selected 20,000 cfs as an average flow for determining a permanent channel prism.

Tide data for Yakutat are shown on page C-15. The mean higher high water is 10.04 ft, highest observed is 15.69 ft and lowest observed is -4.41 ft.

I discussed the potential for lake outlet ice dams at Russell Fiord with Jerry Nibler of NOAA's river forecasting office in Anchorage. To date their office has not observed or been informed of any Alaska lake having outlet damming problems where the outlet is flowing all winter. This is attributed to lack of ice formation near the outlet and a lack of river type flows to move the pack ice towards the outlet during spring breakup. Lakes having ice burgs tend to "ground" the bergs well offshore from the outlets, but this would depend upon individual lake bathometry.

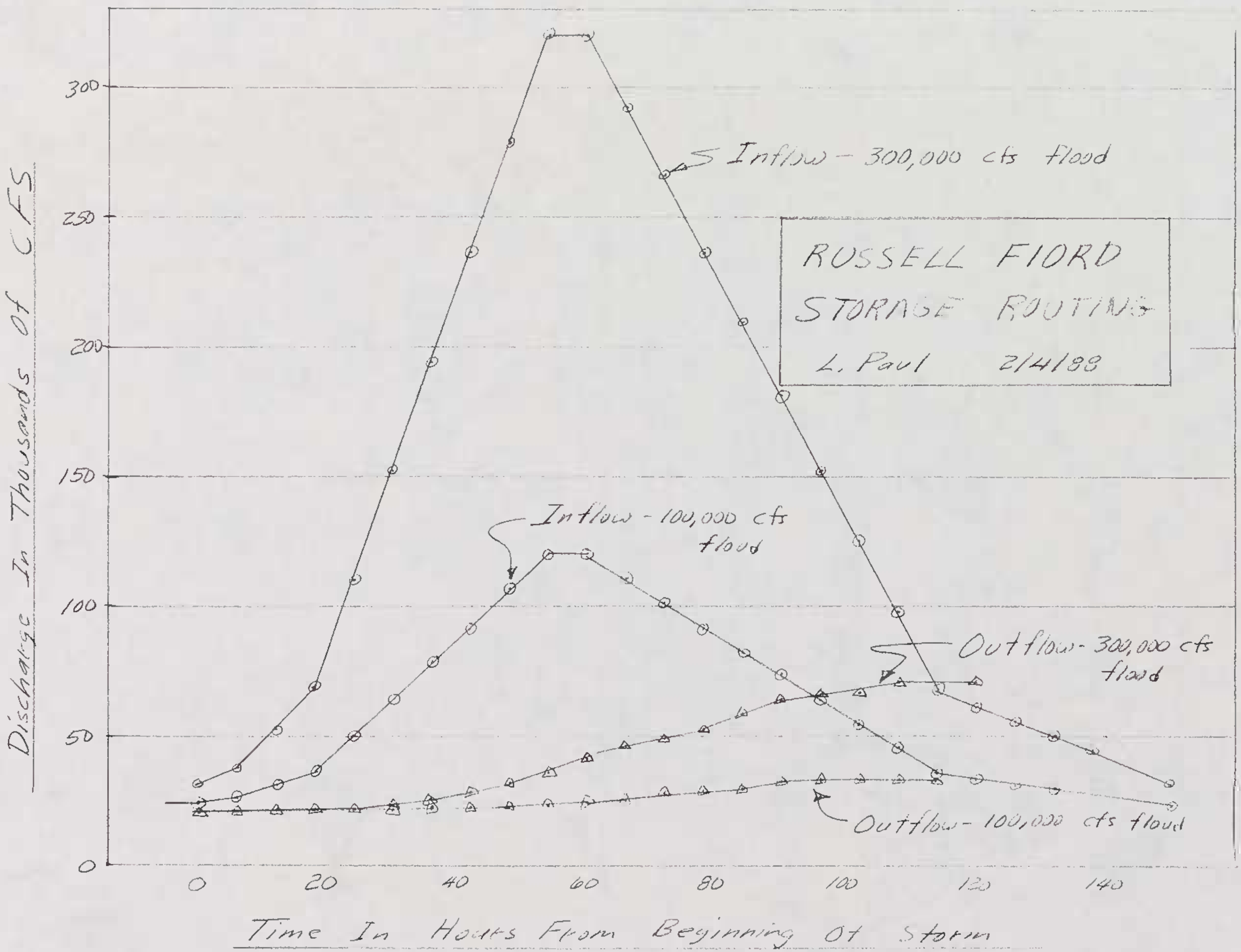
The overflow elevation of 131.1 ft. was determined by Landrum's survey. A location sketch for the saddle is shown on page XC-1.

III. ANALYSIS

A. Russell Lake storage routing. A synthetic inflow hydrograph was developed for Russell Lake. The Mendenhall River Standard Project Flood Hydrograph, developed by the Corps of Engineers, was selected as typical in shape and timing to simulate the Russell Lake watershed. Peak values for the hydrograph are difficult to predict due to lack of historic inflow data and a general lack of good scientific evidence regarding glacier and ice field hydrology for an 800 square mile watershed. Therefore, hydrographs with peak values of 100,000; 200,000; and 300,000 cfs were analyzed to cover the anticipated range of possible floods. Paustian's report developed a peak flow of 220,000 cfs using a 24 hour PMP of 25" and extrapolating the daily lake inflow/precipitation relationship developed during peak snowmelt in August 1986.

Peak outflows and their percentage of the inflow peak for the 3 inflow hydrographs are 33,820 (34%); 47,720 (24%); and 72,117 (24%) cfs respectively. Two of these flows are shown on page 5 and the calculations are included on pages C-1 to C-9. Paustian's 220,000 cfs PMF inflow will produce an outflow of 52,800 cfs using this relationship.

B. DAMBRK. Hydraulic modeling of the Situk flood channels was performed using the National Weather Service DAMBRK computer program developed by Dr. Danny Fread, Silver Springs, Maryland. Steady state flows of 2,000; 10,000; 20,000; 30,000; 40,000; 50,000; 60,000; and 70,000 cubic feet per second (cfs) were modeled using a Mannings friction value of 0.033. A few selected flows were also modeled with a friction value of 0.13 to simulate the existing streamside vegetation. These runs at 0.13 indicated up to 66% height increases in water levels as a result of friction reduced velocities. The random nature of vegetation adjacent to the existing



RUSSELL FIORD
STORAGE ROUTING
L. Paul 2/4/88
Inflow - 300,000 cfs flood
Inflow - 100,000 cfs flood
Outflow - 300,000 cfs flood
Outflow - 100,000 cfs flood
Discharge In Thousands Of CFS
Time In Hours From Beginning Of Storm
0
50
100
150
200
250
300
0
20
40
60
80
100
120
140

channels precludes any detailed analysis using high friction values. It must suffice to indicate that the initial stage heights will be higher than after new channels are established.

C. Analysis process. Stage heights for 10,000 and 50,000 cfs were plotted on the photogrammetrically developed cross sections. These are shown on pages XC-3 to XC-15. The 10,000 cfs flow represents the lower flows anticipated in the Situk drainages. Flows of 20,000 cfs are also contained within the same channel prism and can be described by visual photographic evidence. The 50,000 cfs flow is our best estimate of peak flows that will actually enter the "notch" at Russell Lake outlet after being attenuated by the lake.

The water surface widths were then scaled and transferred to one of the new USGS 1:25,000 scale topographic maps (not included) to develop 10,000 and 50,000 cfs flow widths at the 26 cross sections shown on fold out MAP B. Flow limit lines were then drawn to a "best fit" on the USGS map.

An overlay was used to transfer the 26 cross section widths and flow limit lines from the USGS map to the 1:25,000 scale mosaic photo. Adjustments were then made to best fit visual evidence of historic channels and or vegetation types. The resulting final map of flow limits for 10,000 and 50,000 cfs are shown on fold out MAP C.

D. Future lake levels. The main historic Situk, Dangerous and several smaller streams in the Yakutat forelands have reached equilibrium between gradient, velocity and channel materials. These gradients are in the 0.0012 to 0.0013 range. The Old Situk channel is presently at a gradient of 0.0016 and will continue downcutting until stability is reached. A calculation using a stable gradient of 0.0013 from the ocean to Russell Lake indicates that the eventual lake level will be 123 ft. We have no prediction when this will occur but it is of interest that bedload movement and downcutting of the Old Situk will continue. Primary control for the lake elevation is the glacial moraine that ends at approximately mile post one. The channel in this area is self armored with 2 ft and larger angular stones that have settled out of the moraine as downcutting has occurred (see photos on pg. 6 of Appendix A). The stream channel from mile post 1 to 17 is composed of glacial outwash gravels, sands and silts that are very susceptible to erosion and consequently have limited control over lateral channel movements. Generally, the materials become progressively finer downstream from the moraine.

E. Consequences of increased gradients for the overflow channel. One mitigation option is to construct a channel from the notch directly to mile 13.8 of the Alsek road and continue on to the ocean. A channel in this location would place the first 4 miles in outwash materials at a gradient of 0.0033. Velocity varies with gradient raised to the 0.5 power. The ratio of 0.0033 to 0.0013 is 0.0574/0.0361 = 1.6 higher velocity. The energy of flowing water varies by the velocity squared, therefore the

energy of water at 0.0033 is 2.56 times the energy of water at stable gradient (0.0013). Outwash gravels will erode rapidly at this gradient. Bedload will be transported downstream and deposited at mile post 5 where the gradient changes to 0.0016 causing an alluvial fan to develop with random diversion of the channel. We do not believe the stability of this channel can be maintained without significant volumes of rip-rap and armor rock, both unavailable locally. This option also requires a dam to divert the channel, with associated problems that will not be discussed here.

IV. DISCUSSION

A. Russell Lake outflow. Russell Lake will drastically attenuate all predictable storm events and eliminate the "flashy" type floods usually associated with coastal Alaska drainages. As a result, the overflow channel will not be subjected to frequent violent upsets caused by dramatic short term changes in flow volumes from Russell Lake. Local Situk River watershed floods may produce "flashy" peaks, but their relatively small volumes will not have a significant impact on the flows in the main channel. We have predicted maximum 3 day peak flows in the 50,000 cfs range, however this will be a rare event. Annually, month long base flows of 20,000 to 30,000 cfs will occur. The longer flow periods will have lesser volumes.

B. DAMBRK. The National Weather Service computer model is used nationwide and was used by Dr. Fread's office to predict outflow from the ice dam breach of 10/8/86. We used the model only as a constant flow routing system. The model will run on any PC having 640 K storage and a co-processor (having absolutely nothing else in memory) similar to our COMPAQ 386.

C. Cross sections. One instrument surveyed cross section was established with permanent bench marks tied into Yakutat control stations. This section is at river mile post 0.7 and is plotted on page XC-2. A hand level cross section surveyed at mile post 4.2 was also monumented with a permanent bench mark (not included; photo section is shown on page XC-6). Cross section 11 at mile 5.2 was surveyed and tied to a permanent bench mark using a hand level survey.

The remaining cross sections were produced photogrammetrically with 2 ft vertical detail. Tall vegetation bordering the existing channels reduces accuracy in some areas. Spot details therefore, may not be to the desired accuracy but in general the sections do produce acceptable data for modeling the flows. Additional field surveys will be needed to define site specific details. The connection from the Situk to the Lost River at mile 13 is an example of additional survey needed. The DAMBRK model will not accept wide flat flood plains. Consequently, the flow depths for sections 21 thru 25 were calculated by hand.

D. Final flood limits. The flood limits for 10,000 and 50,000 cfs flows are shown on fold out MAP C and detailed below.

Mile post 0 to 4.5. The channel is well defined from MP 0.3 to 1.0 where it is incised across the moraine containing the Southern end of Russell Fiord. In this section, the channel is lined with angular 2 ft and larger stones that have settled out of the glacial moraine. From MP 1.0 to 4.5 the channel flows thru glacial outwash gravels and is contained within well defined banks. The channel narrowing at MP 3.6 may present opportunities as a bridge location for continued road access to the Dangerous river. We do not anticipate any breakouts from the historic channels in this area.

Mile post 4.5 to 5.5. Although this channel is presently well defined, it has overflow potential to the west during high flows or a debris dam event. Channel material is composed of glacial outwash materials having considerable erosion potential. The present Alsek road culverts at MP 5.2 will be washed out by the overflow.

Mile post 5.5 to 13. Braided channels are evident throughout this section of the river. Their locations are fairly well defined at the 10,000 cfs flows, but lose definition as flows increase to 50,000 cfs. The glacial outwash deposits have been drilled to depths of 700 ft during explorations for oil. No evidence has been found of more resistant material capable of creating a well defined "control section" that would limit meanders and braids. The present channel(s) have local topographic relief that maintain their locations. The 10,000 cfs flow limits on MAP C are reasonably accurate. The 50,000 cfs limits on MAP C are difficult to define. We have assumed an orderly process of vegetative erosion and channel formation, and have purposely identified limit lines as wide circles to indicate the uncertain nature of future events.

Mile post 13 to mouth. The existing Situk river channel from the area of MP 14 to the mouth has a bank full capacity of approximately 10,000 cfs. Higher flows, tidal influence or other factors have produced several interconnections between it and the Lost River area and similar, but limited connections to Kunayosh creek. Cross sections 21 thru 25 indicate that the existing Situk is dwarfed by the Lost River's flood plain. Elevations in the Lost River channel are apparently lower in many locations than parallel sections of the Situk. All that is presently lacking is a connection between MP 13-14 and the Lost River. We believe that the first flows in the 20,000 to 30,000 cfs range will cut thru the existing low saddle in the area of mile 13 and rapidly establish the Lost River as the main channel. Historic evidence for this scenario is found (1) in the archaeological digs adjacent to the Lost River and (2) the mosaic photo that clearly shows parallel vegetated dunes that are truncated and missing between the Lost River and a short continuation to the east at MP 16.5 of the Situk (the lost river road is located on one of these dunes west of the Lost River). When the Lost River is established as the main channel, the

existing Situk may be reduced to an overflow channel or continue as a channel braid.

E. Lost River area. The wide flat grassflats now occupying the Lost River flood plain are probably uplifted remains of former tide flats that developed during previous Russell Lake overflows. A portion, or all, of this area will return to this historic condition. Boundaries are not clearly defined and are shown on MAP C as the 10 ft high tide line. Removal of these grassflats and the present sinuous Lost River channel should improve the function of side drainages from the airport and other areas.

F. Ocean entrance. With the Lost River established as the main channel, the ocean entrance will assume the historic "straight shot" bordered on the west by the existing foredune. The present Situk ocean entrance may close as the Blacksand Spit migrates west. The Ahrnklin and Kunayosh system could then follow west behind the beach dune to the Lost River and become minor partners in the ocean entrance.

G. Effects of vegetation. The overflow will eventually establish a main channel prism devoid of vegetation. This channel will accommodate the average annual flow of around 20,000 cfs. Existing vegetation will be washed out at the roots, sorted by the stream, deposited at random locations, buried by bedload or washed out to sea. During this process trees with root wads attached will form debris dams causing stream diversions, elevated water levels, sudden outwashes of debris and other combinations of channel upset.

As the channel flow increases it will tend to increase in depth up to the historic bank height. A 20,000 cfs flow can occupy the same width as 10,000 cfs with some flow in streamside vegetation caused by the elevated water surface.

The actual channel width is difficult to predict by calculations. We are fortunate that much of the historic flood plain is still visible using aerial photos and cross sections. Widths for the sections are:

Section	Annual Flow Width
MP 0.3 to 1.0	300 to 400 ft within the "notch" area. Well defined.
MP 1.0 to 6.5	600 to 1000 ft within fairly well defined banks.
MP 6.5 to 10.5	Major braided section begins at MP 7. No well defined annual flow areas. Total widths up to 7000 ft. Possible "islands" within braided areas.
MP 10.5 to 12.5	1000 to 1500 ft within fairly well defined banks.
MP 12.5 to mouth	Situk channel gets progressively narrower as flows are diverted to Lost River or Kunayosh creek areas. 1200 ft wide at MP 12.5; 800 at MP 14; and 200 ft from MP 15 to the mouth.

The Lost River channel is not well defined on photos between MP 12.5 and 14.0. Side drainages from the Yakutat area may have masked historic evidence. Field investigations are needed to verify widths.

V. MITIGATION OPTIONS

A. Separate canals. The 8/20-21/86 trip report contained in Appendix A discusses canal options. Any canal that significantly reduces the existing 17 mile length of river outlet will increase the stream gradient causing erosion, downcutting and instability in the new channel. Sources of rip-rap have not been developed locally adding to the cost of stabilizing any new channel against erosion.

A canal that parallels the existing Situk from mile 5.5 to the ocean would cause the least reduction in channel length. Long term stability would require significant amounts of imported armor or rip-rap material to line the canal against lateral movement and even this can not guarantee that a major flood would not overtop and make a significant change in alignment.

We have not developed any additional details regarding separate canals.

B. Maintain in existing channel. The existing historic channel will contain the overflow providing it has the opportunity to redevelop itself without major upsets caused by debris jams. Vegetation in the 20,000 cfs channel prism could be managed to reduce it's potential for debris jams by flush cutting all woody stems over 1 inch diameter and (1) removing from the site or (2) bucking into 6 ft minimum lengths, cutting all limbs over 1 inch diameter and leave material on the ground. Additional control surveys would be needed to verify the channel location and provide a basis for setting clearing limits. Trees older than 150 years should be left in place because they have survived previous overflows.

In addition, it may be possible to use local materials for construction of some nominal dikes and channels for initial channel control between MP 5.5 and 10.5 where braiding is most evident. Field surveys are needed to verify this option.

C. Continued road access past Old Situk river. We developed a conceptual proposal to replace the existing culverts at the Old Situk road crossing with a 600 ft bridge to maintain access east of the Old Situk River. A detailed survey may indicate the site is less than desirable due to flooding of the Alsek road near the West abutment.

Another site at mile 3.6 appears to be feasible. Photographic analysis indicates a narrow width well contained by channel banks. Field analysis and surveys would be needed to verify this observation. Some road construction would be needed to implement this bridge crossing alternative.

VI. FUTURE ANALYSIS

This report is based on the best hydrologic, photogrammetric and field survey data currently available. It can serve as a planning tool and basis for future hydraulic analysis. Distances and elevations have generally been obtained by photogrammetric methods. Any site specific details or plans for engineering works will require field surveys to establish horizontal and vertical control.

Areas of hydraulic interest for the immediate future are:

A. Field surveys are needed between mile post 13 and the Lost River to determine historic or future channels.

B. Investigation of a bridge crossing site at mile post 3.6 is needed if a decision is made to maintain road access past Alsek road mile 11.

C. A decision regarding vegetation management in the main overflow channel is needed as soon as possible. If clearing is proposed, field surveys will be required to define the 10,000-20,000 cfs channel prism in the areas selected for clearing and to establish clearing limits in the field. The actual clearing could be accomplished during a three or four month construction operation.

D. The hydrology for this report assumes the Hubbard Glacier watershed <u>does not</u> contribute any flow to Russell Lake. We encourage your technical input on the validity of this very basic assumption.

E. The Chatham Area is continuing to research alternative procedures for developing a lake inflow hydrograph.

CROSS SECTION INDEX

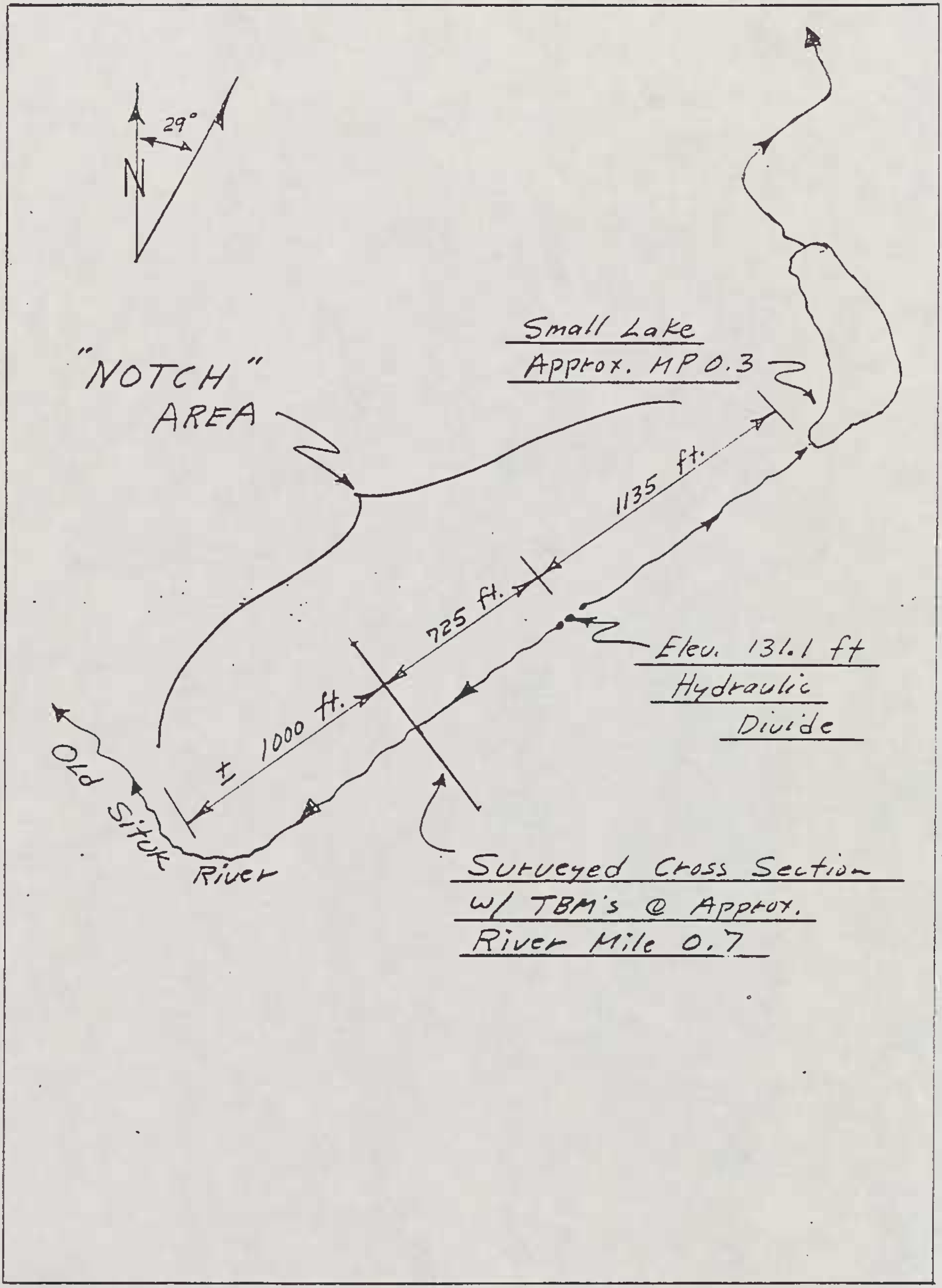
CROSS SECTION INDEX

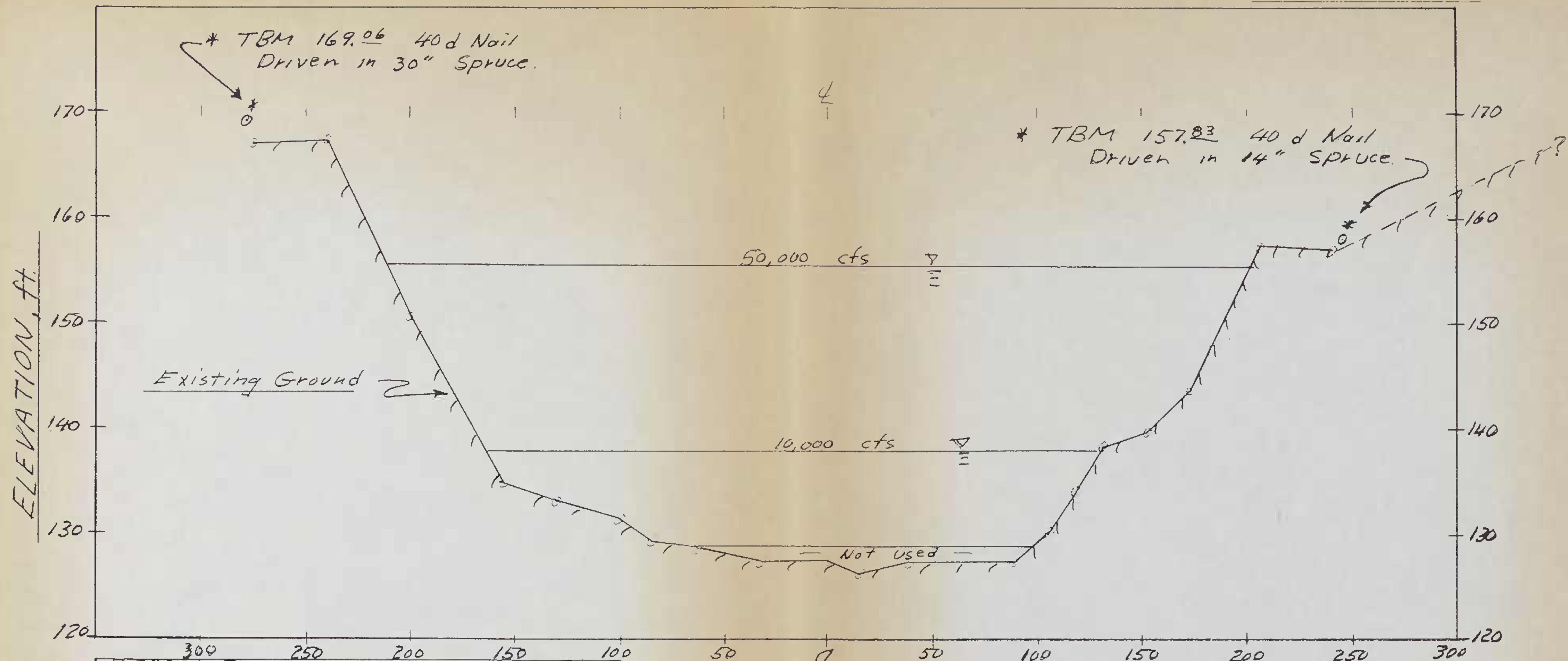
NOTES

1. All sections are viewed looking downstream.

2. Unless otherwise indicated the scales are: 1" = 1000 ft. Horizontal
   1" = 20 ft. Vertical

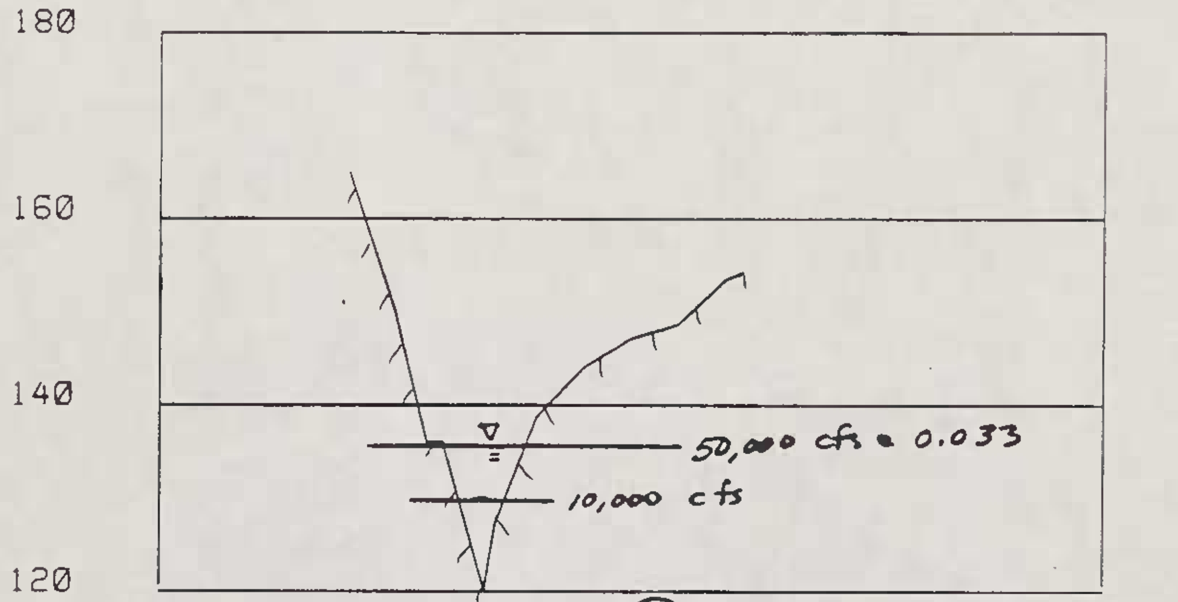
3. The "photo" sections were all developed using photogrammetric methods.


29°
N
"NOTCH" AREA
Small Lake
Approx. MP 0.3
1135 ft.
725 ft.
± 1000 ft.
Elev. 131.1 ft
Hydraulic
Divide
Old Situk River
Surveyed Cross Section
w/ TBM's @ Approx.
River Mile 0.7



STAGE ft.	ELEV ft.	Σ AREA ft^2	VEL fps	Q ft^3/sec.
32	161	11,410	6.5	74,165
30	159	10,400	6	62,400
28	157	9,490	6	56,940
26	155	8650	5.5	47,575
24	153	7840	5.5	43,120
22	151	7040	5.5	38,720
20	149	6270	5.5	34,485
18	147	5510	5	27,550
16	145	4780	5	23,900
14	143	4070	5	20,350
12	141	3390	5	16950
10	139	2730	4.5	12,285
8	137	2140	4	8560
6	135	1580	4	6320
4	133	1050	4	4200
2	131	600	3	1800
0	129	220	3	660

SECTION IN "NOTCH"
OLD SITUK RIVER M.P. 0.7
Surveyed 10/26/87 J. Landrum
1" = 50 ft Horiz. 1" = 10 ft. Vert.



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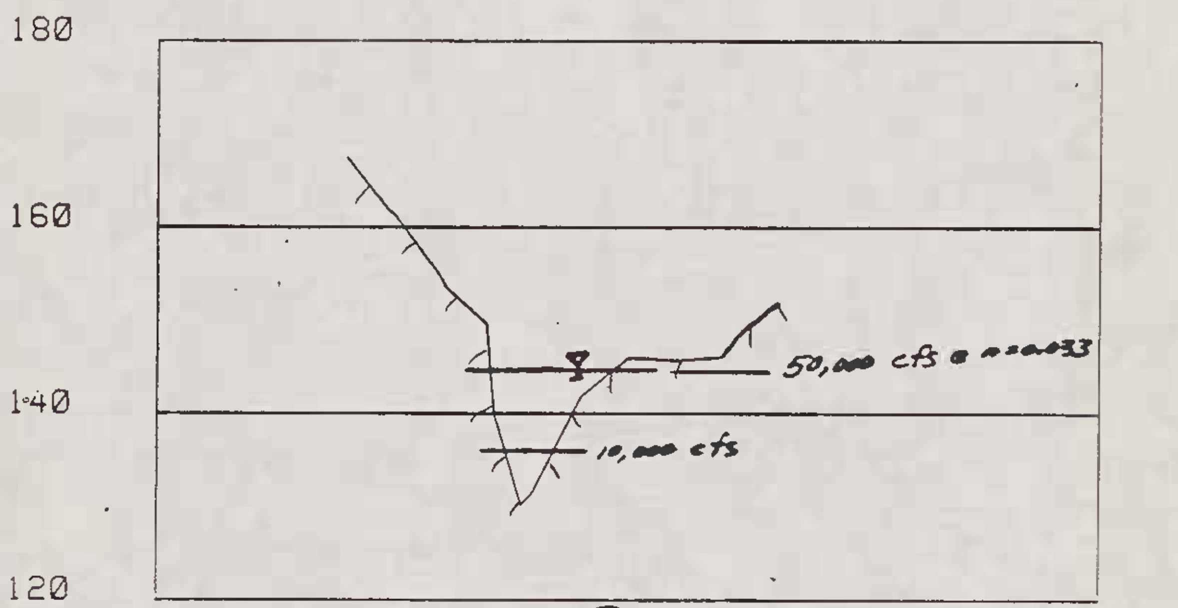
* OLD SITUK RIVER



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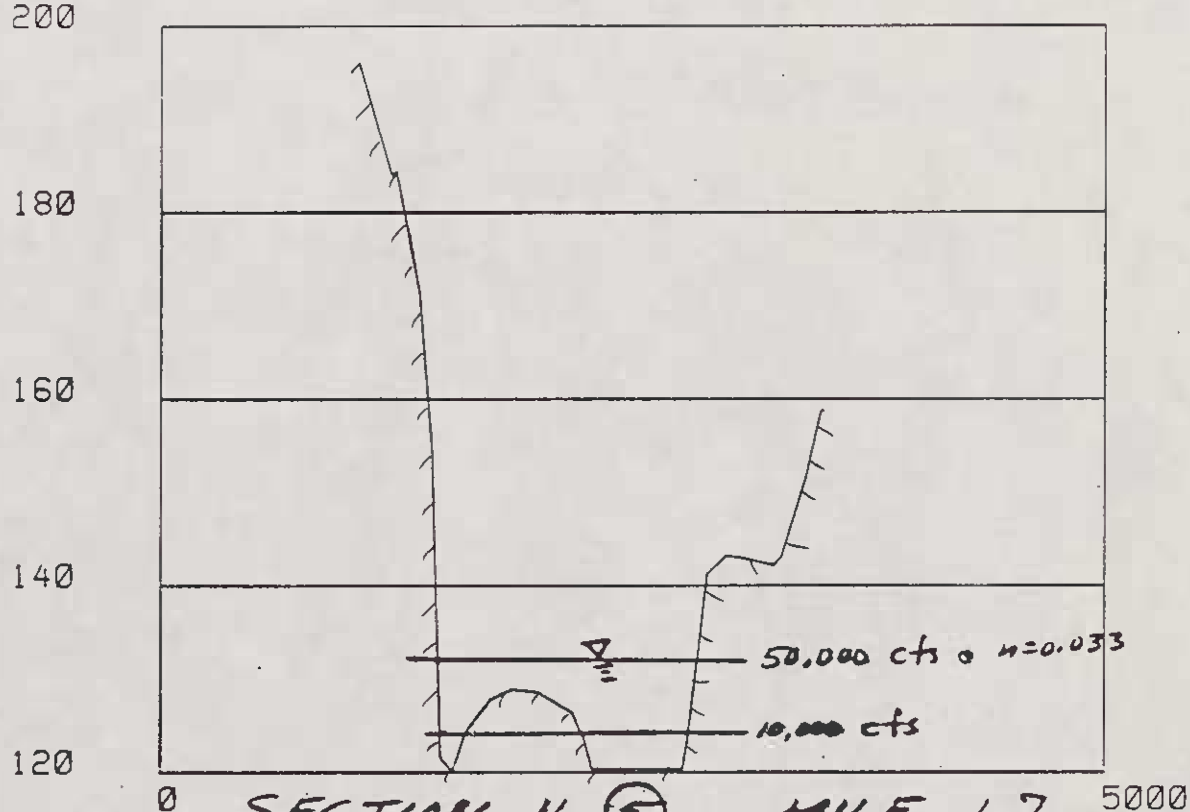
* OLD SITUK RIVER



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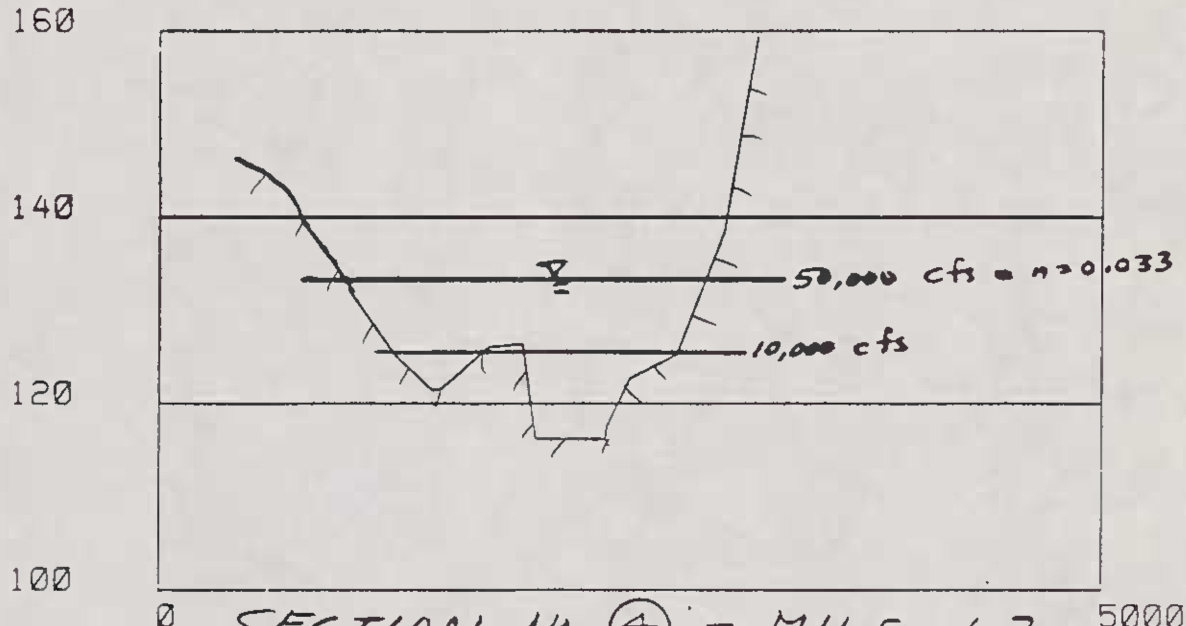
* OLD SITUK RIVER



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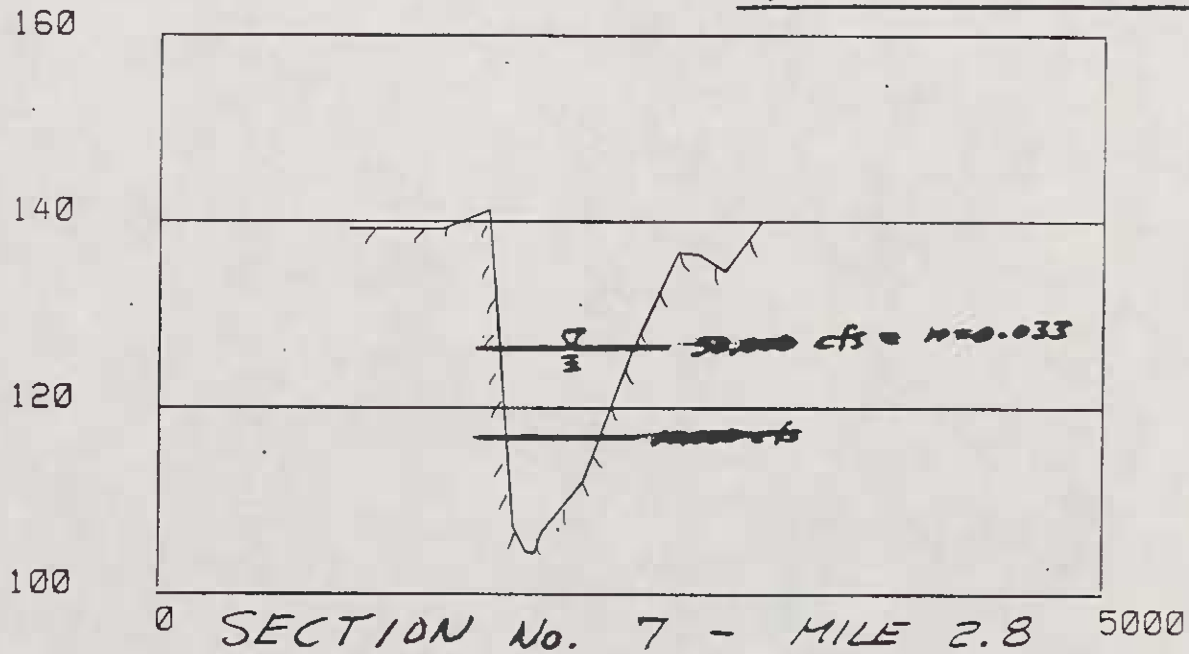
* OLD SITUK RIVER



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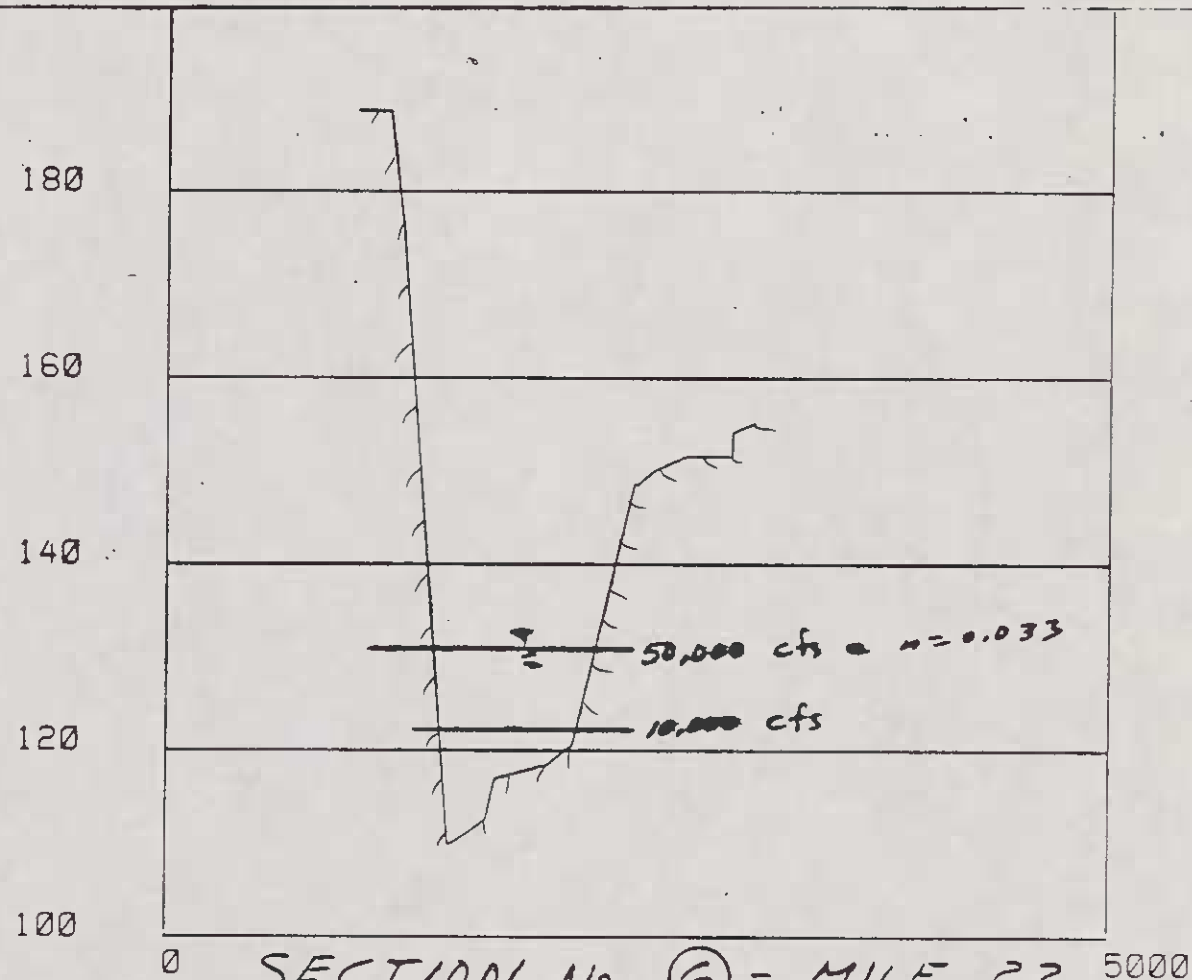
* OLD SITUK RIVER



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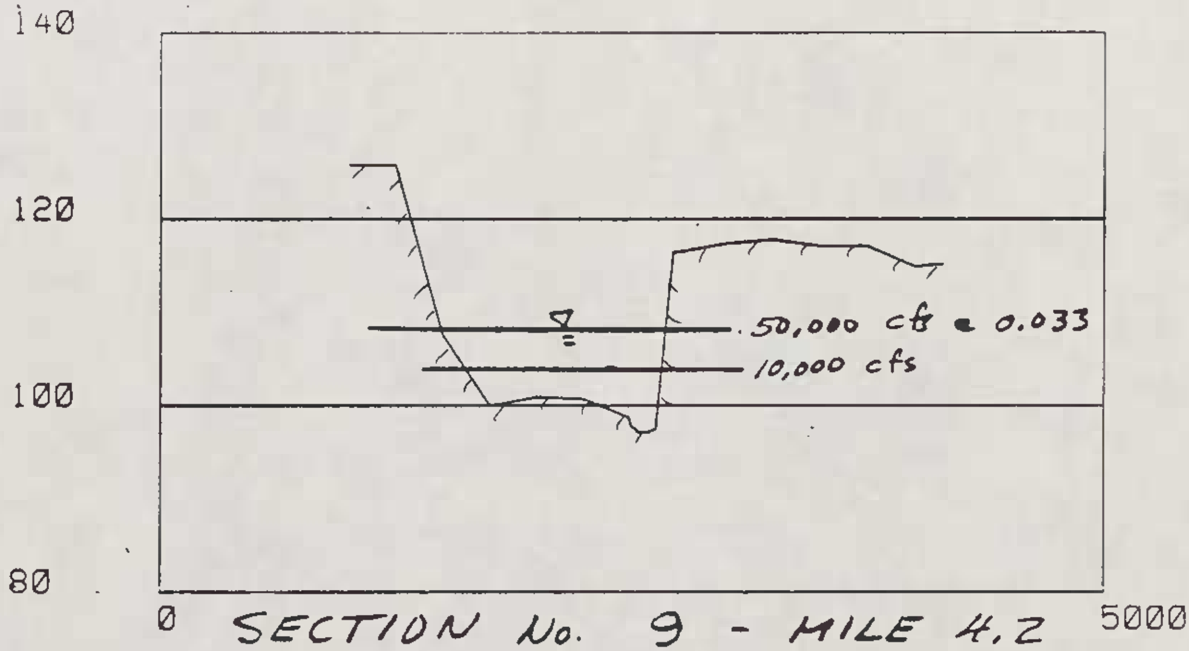
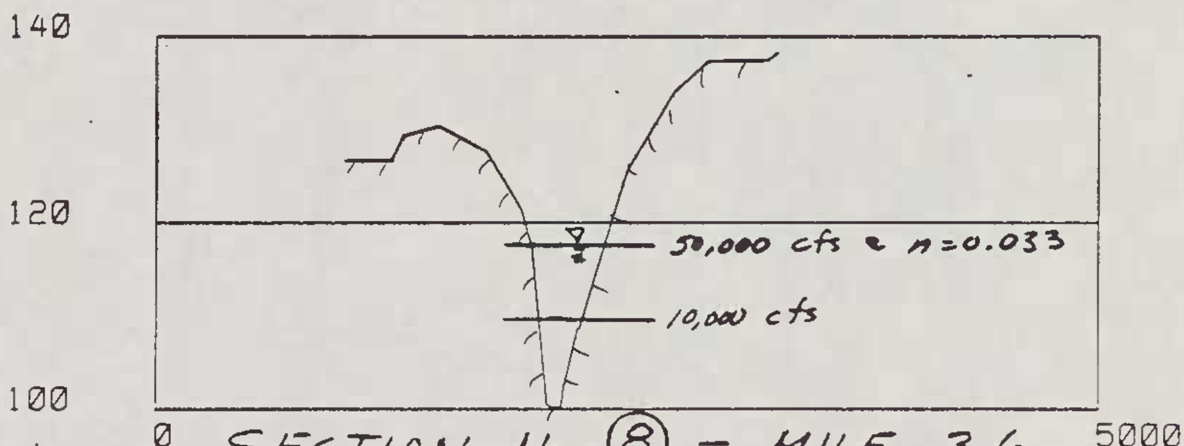
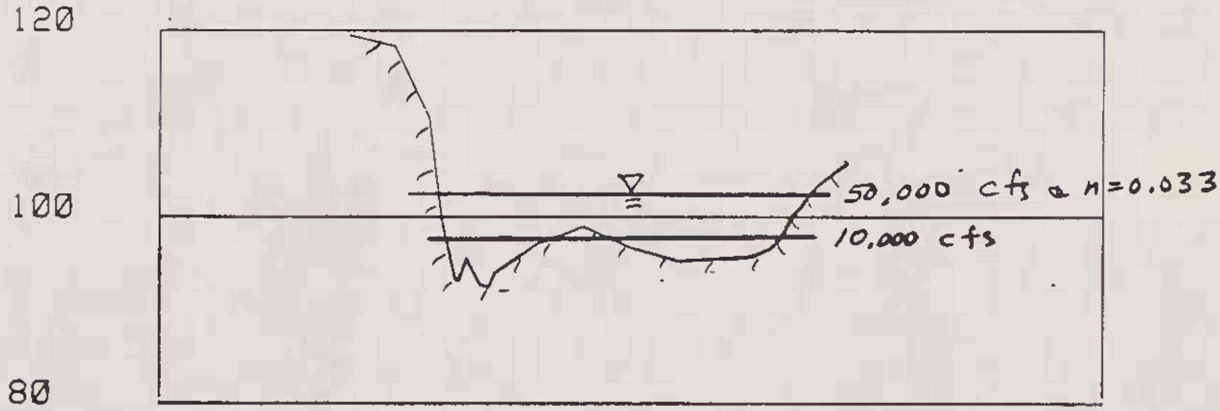
* OLD SITUK RIVER



SECTION No. 9 - MILE 4.2
* OLD SITUK RIVER

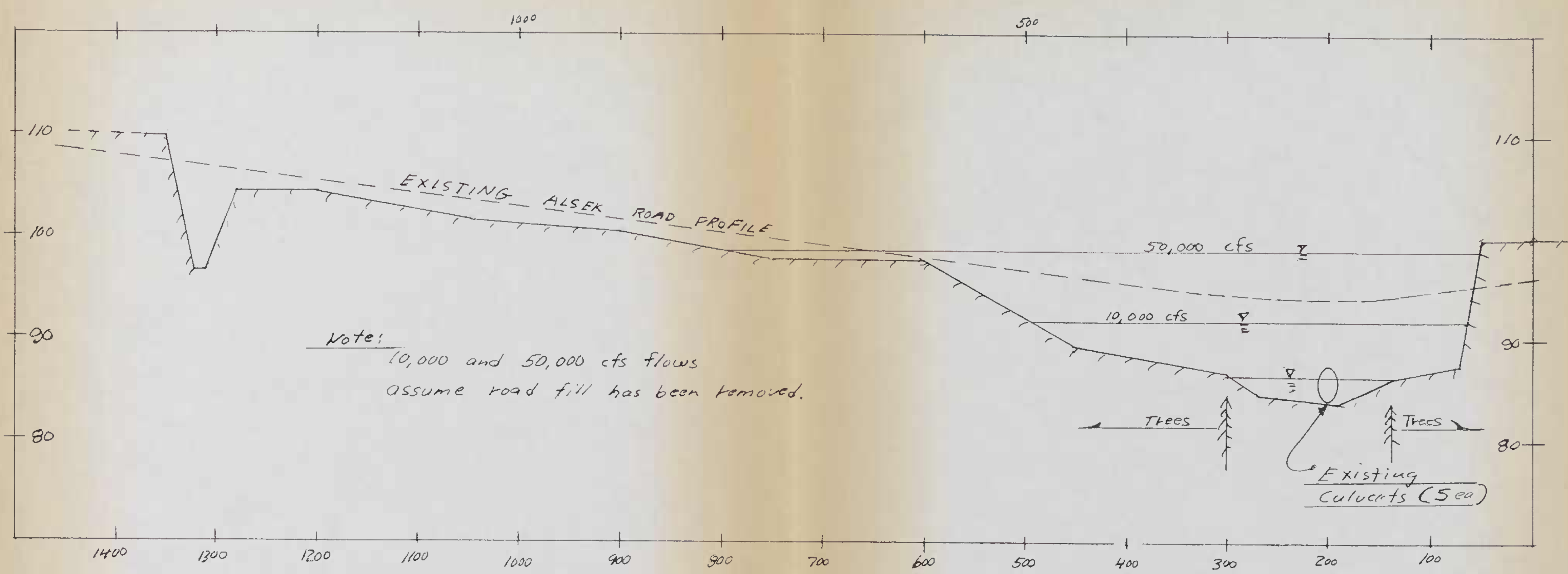


SECTION No. 8 - MILE 3.6
* OLD SITUK RIVER



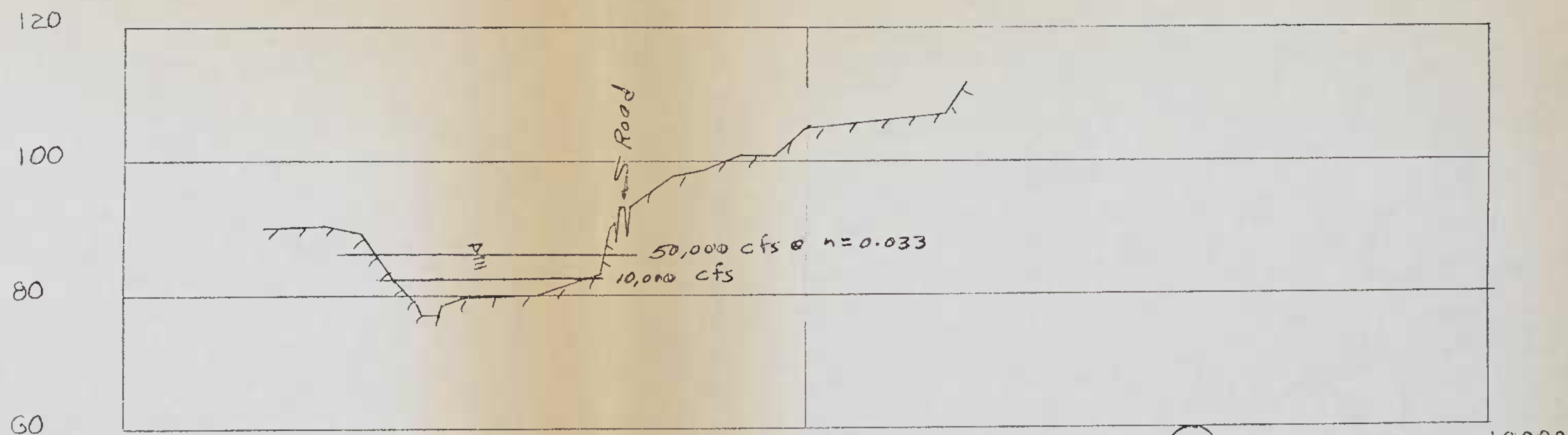
SECTION No. 10 - MILE 4.7

* OLD SITUK RIVER

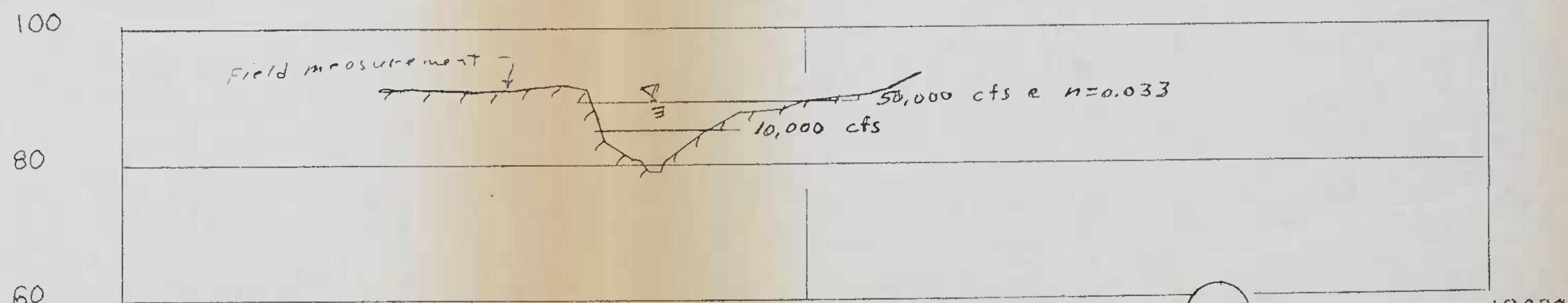


Hand level survey
5/18/87
L. Paul, G. Wilson, S. Poustian

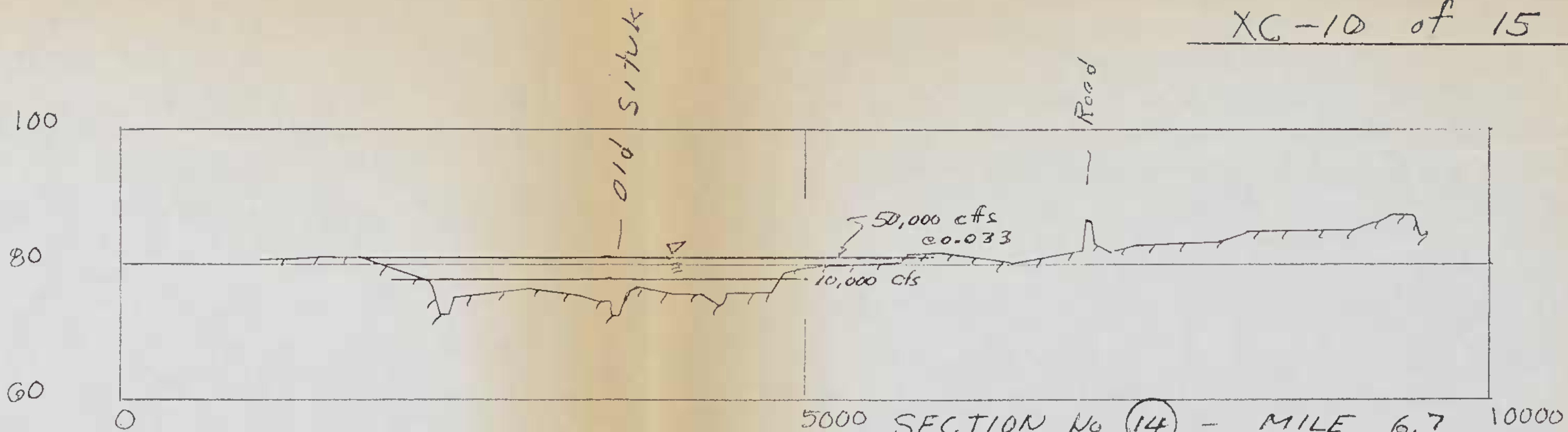
DAMBRK SECTION 11 @ RIVER MILE 5.2
OLD SITUK RIVER
@ ALSEK ROAD
1" = 100 ft HORZ.
1" = 10 ft VERT.



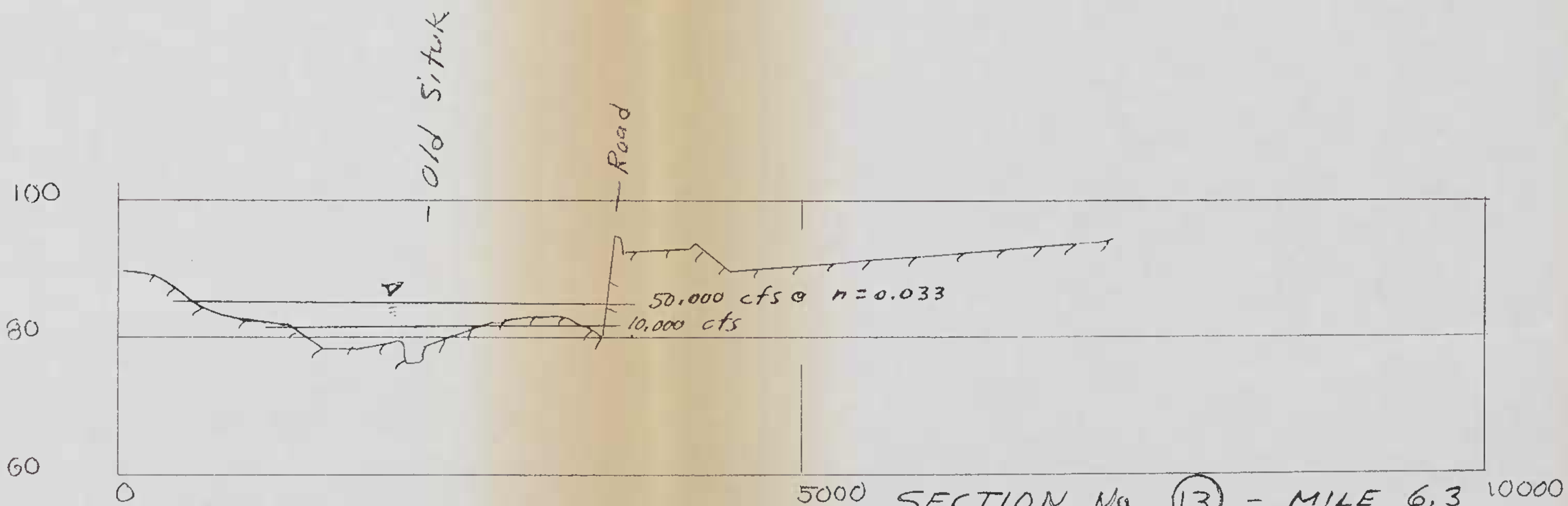
SECTION No. 12 - MILE 6.0
OLD SITUK RIVER



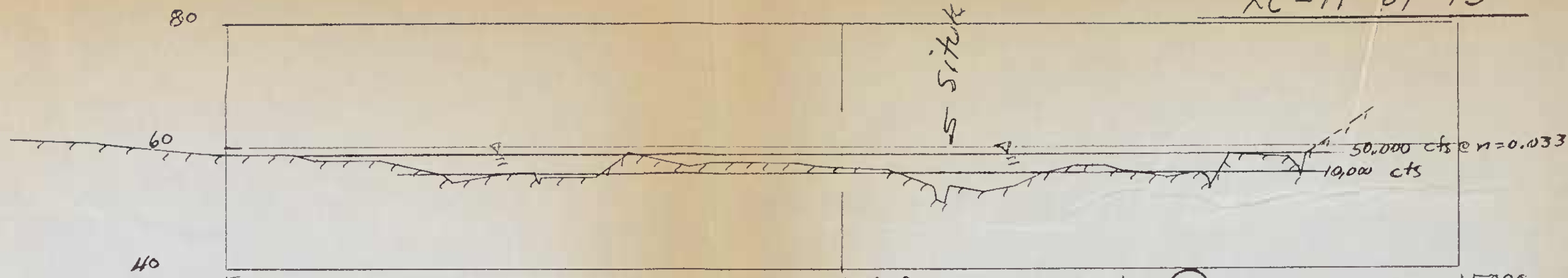
SECTION No 11A - MILE 5.7
OLD SITUK RIVER



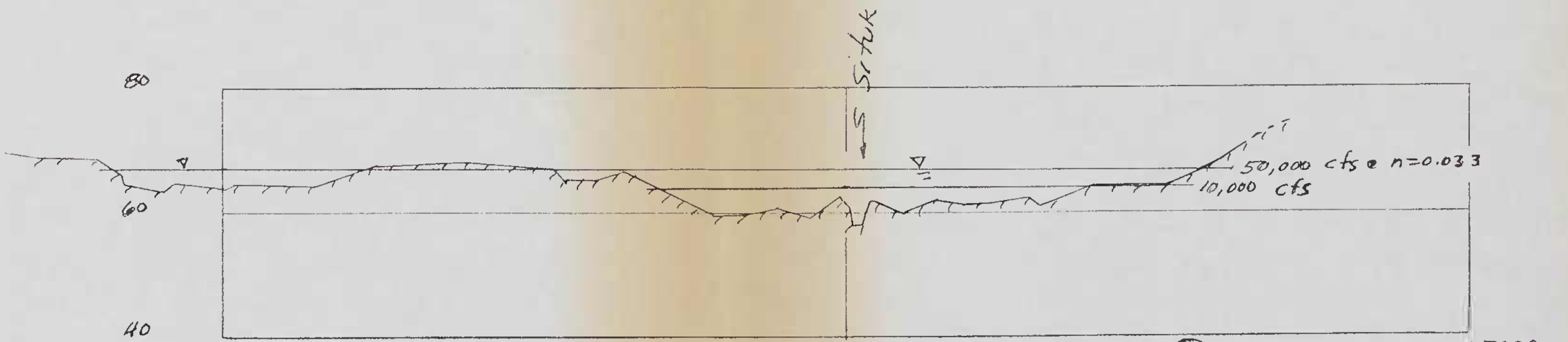
SECTION No (14) - MILE 6.7
OLD SITUK RIVER



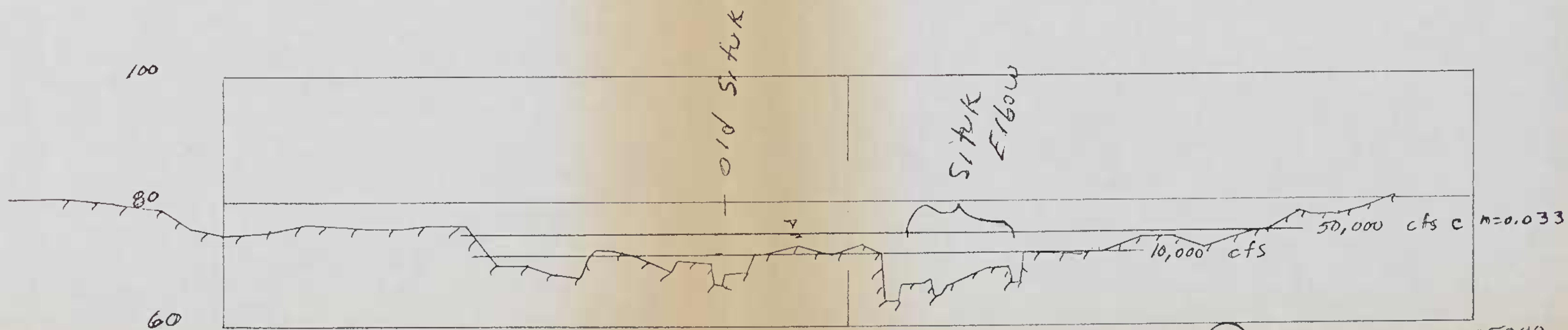
SECTION No. (13) - MILE 6.3
OLD SITUK RIVER



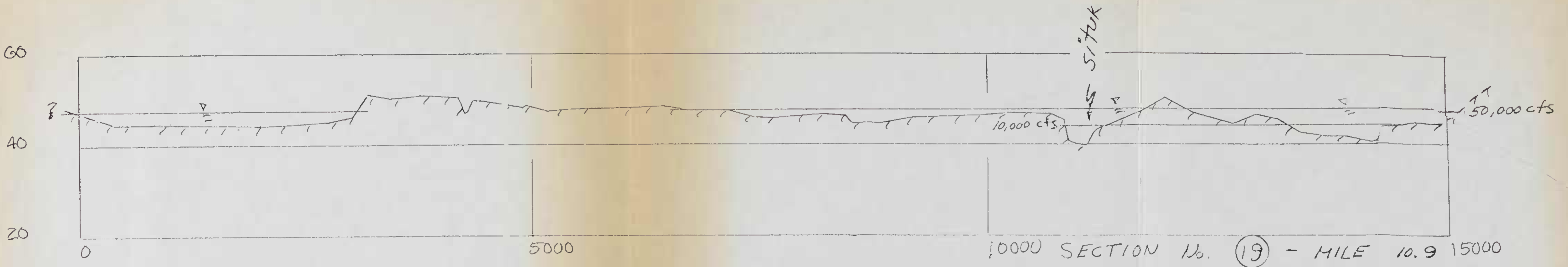
SECTION No (17) - MILE 9.4
SITUK RIVER



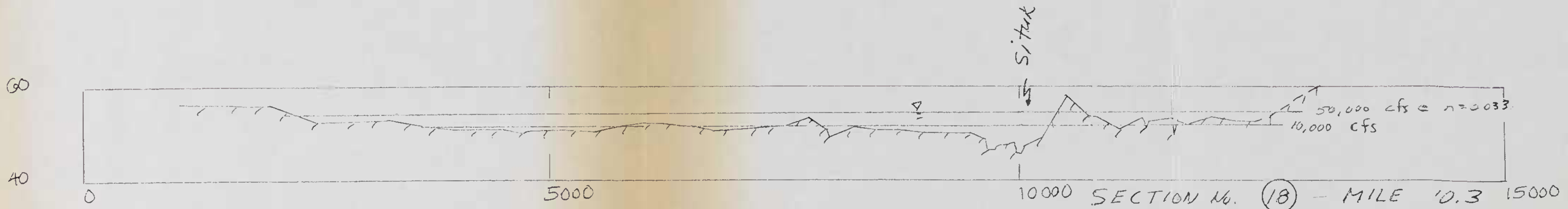
SECTION No. (16) - MILE 8.4
SITUK RIVER



SECTION No. (15) - MILE 7.3
OLD SITUK & SITUK RIVERS

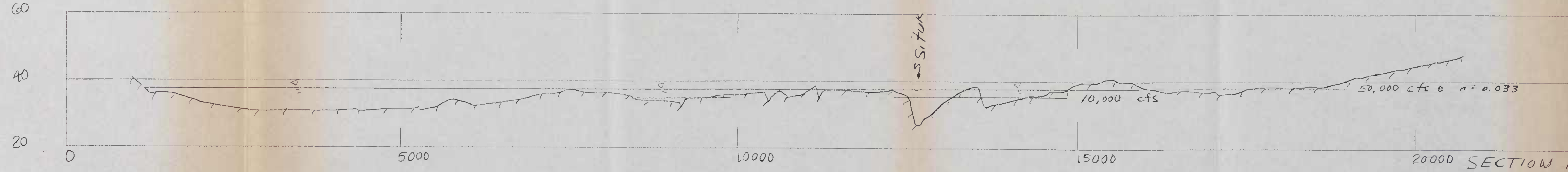


SECTION No. (19) - MILE 10.9
SITUK RIVER



SECTION No. (18) - MILE 10.3
SITUK RIVER

SECTION No. 21 - MILE 13.3
SITUK & LOST RIVERS



SECTION No 20 - MILE 12.2
SITUK RIVER


40
20
0
Kunayosh
Kunayosh
Situk
Lost River Area
250,000 cfs
50,000 cfs
10,000 cfs
MHHW
El. 10.0
0
5000
10000
15000
20000
25000
SECTION No. 23 - MILE 15.0
30000
SITUK + LOST RIVERS
35000


40
20
0
Kunayosh
Kunayosh
Kunayosh
Situk
Lost River Area
End of Airport
Elev. 22.9
200,000 cfs
10,000 cfs
50,000 cfs
0
5000
10000
15000
20000
25000
SECTION No 22 - MILE 14.2
30000
SITUK + LOST RIVERS
35000

XC-15 of 15

Tide Data:

Highest Observed Water Level (3/28/64) $15^{\underline{7}}$ ft.
Mean Higher High Water (MHHW) = $10^{\underline{04}}$ ft.
Mean High Water (MHW) = $9^{\underline{2}}$ ft.
Mean Tide Level (MTL) = $5^{\underline{3}}$ ft.
Mean Low Water (MLW) = $1^{\underline{4}}$ ft.
Mean Lower Low Water (MLLW) = 0^{0} ft.
Lowest Observed Water Level (11/22/72) = $-4^{\underline{4}}$ ft.

SECTION No. 25 - MILE 17.0
SITUK & LOST RIVERS

SECTION No. 24 - MILE 16.1
SITUK & LOST RIVERS

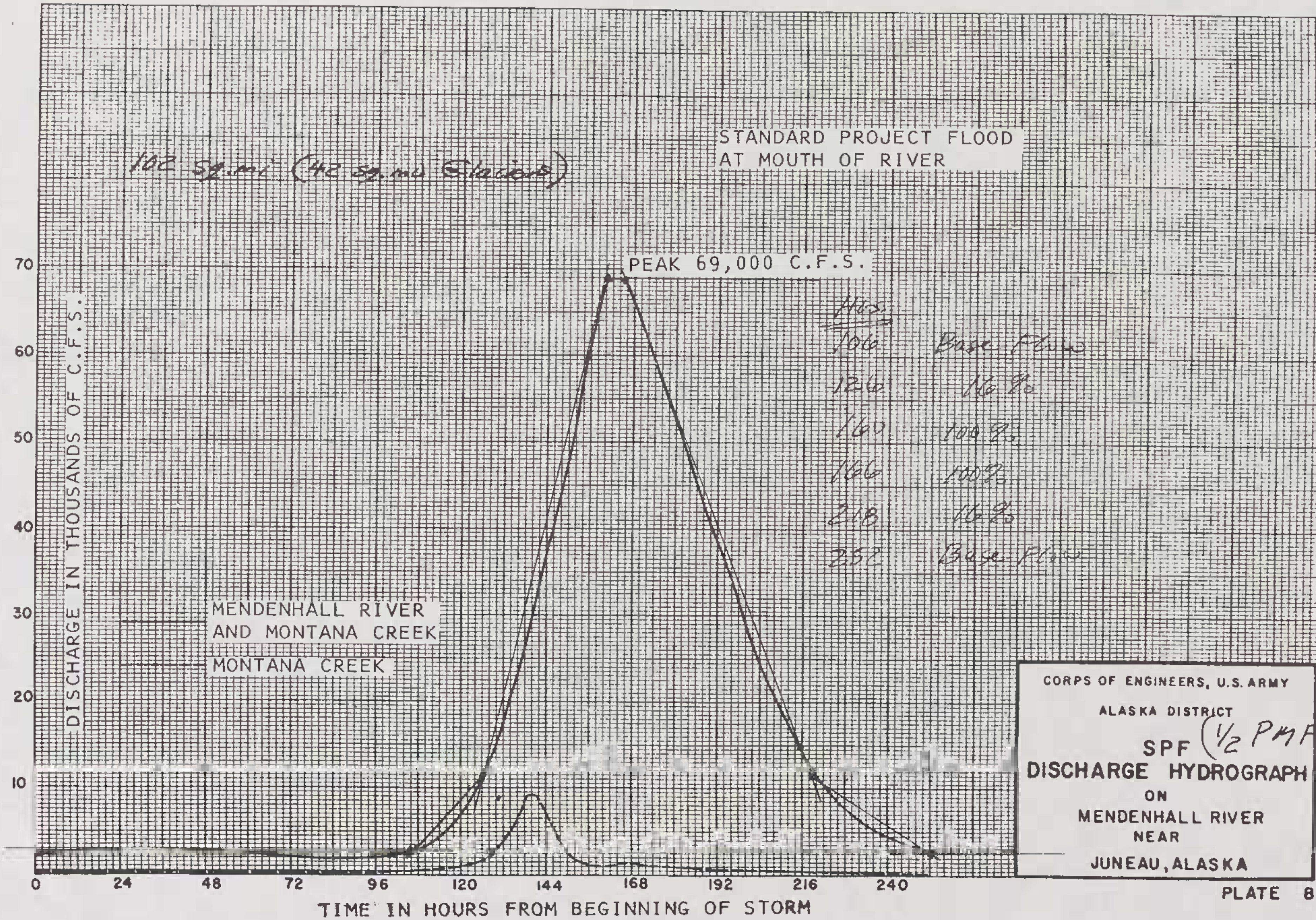
CALCULATIONS INDEX

CALCULATIONS INDEX

C-1/15
L. Paul

Synthetic Inflow Hydrograph
(See Mendenhall River Discharge Hydrograph)

Time hrs	% of Max.		MAXIMUM Q 100,000 cfs	200,000 cfs	300,000 cfs		
0	Base(4%)		4000	8,000	12,000		
6	6		6,000	12,000	18,000		
12	11		11,000	22,000	33,000		
18	16%		16,000	32,000	48,000		
24	30		30,000	60,000	90,000		
30	44		44,000	88,000	132,000		
36	58		58,000	116,000	174,000		
42	72		72,000	144,000	216,000		
48	86		86,000	172,100	258,000		
54	100%		100,000	200,000	300,000		
60	100		100,000	200,000	300,000		
66	91		91,000	182,010	273,000		
72	82		82,000	164,000	246,000		
78	72		72,000	144,000	216,000		
84	63		63,000	126,000	189,000		
90	54		54,000	108,000	162,000		
96	44		44,000	88,000	132,000		
102	35		35,000	70,000	105,000		
108	26		26,000	52,000	78,000		
114	16%		16,000	32,000	48,000		
120	14		14,000	28,000	42,000		
126	12		12,000	24,000	36,000		
132	10		10,000	20,000	30,000		
138	8		8000	16,000	24,000		
144	6		6,000	12,000	18,000		
150	Base(4%)		4,000	8000	12,000		
156							
162							
168							



CORPS OF ENGINEERS, U.S. ARMY

ALASKA DISTRICT

SPF (1/2 PMF)

DISCHARGE HYDROGRAPH

ON

MENDENHALL RIVER

NEAR

JUNEAU, ALASKA

PLATE 8

Storage Routing Computation Steps.

1. Average 2 flows from 3 and enter in 4
2. Multiply 4 times 6 hrs = 4(21,600) and enter in 5
3. Assume Trial elevation and enter in 6
   (Subtract previous 9 from 5 and ÷ 266 = Δh)
4. Average 2 flows from 7 and enter in 8
   (See XC-2 for Outflow volumes)
5. Multiply 8 by 6 hrs = (8)(21,600) and enter in 9
6. Subtract 9 from 5 and enter in 10
7. Divide 10 by 266 for Δh in 10
   (Page C-12. @ elev. 140, Vol per 0.1 ft rise = 266×10^6 ft^3)
8. 11 is Σ of 10
9. Add Σh in 11 to initial elevation at time 0.
   Enter in 12
10. Compare 12 against trial elev in 6
11. Redo w/ new trial or continue to next time step.

① Time	② Δt hrs	③ I cfs (Add Base Flow 20,000)	④ Avg. I cfs	⑤ I Volume $ft^3 \times 10^6$	⑥ Trial Elev.	⑦ O cfs	⑧ Avg. O cfs	⑨ O Volume $ft^3 \times 10^6$	⑩ ΔS $ft^3 \times 10^6$ (Δh, ft)	⑪ Total Storage $ft^3 \times 10^6$ (Σh, ft)	⑫ Resvr. Elev.	Remarks
											131.0	- Chnl elev
0		24 000				20,000					144.0	(Assume section similar to MP 0.7 w/ adjusted elevations Stage = 13.0 ft
	6		25,000	540.0	144.1		20,050	433.6	107.0 (+0.04)	107 (+0.04)		
6		26,000				20,100					144.04	
	6		28,500	615.6	144.1		20,150	435.2	180 (0.06)	287 (+0.1)		
12		31,000				20,200					144.1	
	6		33,500	723.6	144.2		20,300	433.4	29[illegible] (+0.1)	572 (+0.2)		
18		36,000				20,400					144.2	
	6		43,000	928.8	144.4		20,650	446	482 (+0.18)	1054 (+0.38)		
24		50,000				20,700					144.38	
	6		57,000	1,231	144.6		20,950	452	[illegible] (+0.31)	1833 0.63	144.63	
30		64,000				21,000						
	6		71,000	1,533	145.0		21,150	456	1,077 (+0.4)	2910 (1.08)	145.08	
36		78,000				21,300						
	6		85,000	1,836	145.6		21,700	468	1368 +(0.51)	4278 (1.59)	145.59	
42		92,000				22,100						
	6		99,000	2,138	146.2		22,450	485	1653 +(0.62)	5931 (2.21)	146.21	
48		106,000				22,800						
	6		113,000	2440	146.9		23250	502	1938 (+0.73)	7869 (2.94)	146.94	
54		120,000				23 700						
	6		120,000	2592	147.7		24,200	523	2069 (+0.78)	9938 (3.72)	147.72	
60		120,000				24,700						
	6		115,500	2495	148.5		25,300	546	1949 (0.73)	11,387 (4.45)	148.45	
66		111,000				25900						

RUSSELL FIORD STORAGE ROUTING
STORM PEAK = 100,000 cfs
Initial Base Flow = 20,000 cfs
(Hydrograph Time from Mendenhall River Standard Project Flood)

C-4/15

(1) Time	(2) Δt hrs	(3) I cfs	(4) Avg. I cfs	(5) I Volume $ft^3 \times 10^6$	(6) Trial Elev.	(7) O cfs	(8) Avg. O cfs	(9) O Volume $ft^3 \times 10^6$	(10) ΔS $ft^3 \times 10^6$ (Δh, ft)	(11) Total Storage $ft^3 \times 10^6$ (Σh, ft)	(12) Reserv. Elev.	Remarks
66		111,000				25900						
	6		106500	2300	149.0		26950	582	1718 (+0.64)	13,605 (5.29)	149.09	increase velocity to 5 fps. (Out)
72		102,000				29 000						
	6		97,000	2095	149.6		28480	615	1480 (+0.56)	15085 (5.65)	149.65	
78		92,000				28960						
	6		87,500	1 890	150.1		29 360	634	1256 (+0.47)	16,341 (6.12)	150.12	
84		83,000				29760						
	6		78 500	1696	150.5		31,120	672	1024 0.38	17,365 6.5	150.5	
90		74,000				32,480						increase vel to 6.0
	6		69000	1490	150.9		32,865	710	780 0.29	18,145 6.79	150.79	
96		64,000				33,250						
	6		59,500	1285	151.2		33,535	724	561 0.21	18,706 7.0	151.0	
102		55,000				33 820						
	6		50,500	1090	151.2		33820	730	360 0.13	19,066 7.13	151.13	
108		46,000				33820						
	6		41,000	885	151.2		33820	730	155 0.05	19,221 7.18	$\boxed{151.18}$	$\boxed{\text{say } 151.2}$
$\boxed{114}$		36,000				$\boxed{33820}$						− 144.0
			35000	756	151.2		33820	730	26 —	—	—	Add 7.2
120		34,000				33820						Stage 13.0
			33,000	712								
126		32 000										20.2 Max Stage.
			31,000	669								
132		30,000										

Maximum Q = 33,820 cfs.

Crest @ Notch 114 hrs into flood @ 20.2 ft stage = elev. 151.2

0-5/15

① Time	② Δt hrs	③ I cfs (Add Base flow = 20,000)	④ Avg. I cfs	⑤ I Volume $ft^3 \times 10^6$	⑥ Trial Elev.	⑦ O cfs	⑧ Avg. O cfs	⑨ O Volume $ft^3 \times 10^6$	⑩ ΔS $ft^3 \times 10^6$	⑪ Total Storage $ft^3 \times 10^6$	⑫ Reserv. Elev.	Remarks $266 \times 10^6\ ft^3/0.1\ ft$ Rise (Δh)
									(Δh, ft.)	(Σh, ft)	131.0	Crest elev.
0		28,000				20,000					144.0	Stage = 13.0 ft
	6		30,000	648	144.1		20,100	434	214 (0.08)	214 (0.08)		Section similar
6		32000				20,200					144.08	to M.P. 0.7 w/
	6		37,000	799	144.2		20,300	438	361 (0.14)	575 (0.22)	144.22	adjusted elevations.
12		42000				20,400						
	6		47,000	1015	144.4		20,500	442	573 (0.21)	1148 (0.43)	144.43	
18		52000				20,600						
	6		66,000	1425	144.8		20940	452	973 (0.37)	2121 (0.80)	144.8	
24		80000				21280						
	6		94,000	2030	145.4		21760	470	1560 (0.59)	3681 (1.39)	145.39	
30		108000				22240						
	6		122,000	2635	146.2		22880	494	2141 (0.81)	5822 (2.20)	146.20	
36		136000				23520						
	6		150,000	3240	147.2		24320	525	2715 (1.0)	8537 (3.20)	147.2	
42		164000				25120						
	6		178,000	3845	148.4		26,080	563	3282 (1.23)	11,819 (4.43)	148.43	
48		192000				27040						
	6		206,000	4450	149.8		28624	618	3832 (1.44)	15,651 (5.87)	149.87	
54		220000			~~1.6~~	30,208						
	6		220,000	4752	151.4		31,616	682	4070 (1.53)	19,721 (7.41)	151.40	
60		220000			1.5	33,024						
	6		211,000	4557	152.9		34,344	742	3815 (1.43)	23,536 (8.83)	152.83	
66		202000			1.3	35,664						
					154.2							

RUSSELL FIORD STORAGE ROUTING
200,000 cfs Storm Pair
Base Flow = 20,000 cfs

C-6/15

(1) Time	(2) Δt hrs	(3) I cfs	(4) Avg. I cfs	(5) I Volume $ft^3 \times 10^6$	(6) Trial Elev.	(7) O cfs	(8) Avg. O cfs	(9) O Volume $ft^3 \times 10^6$	(10) ΔS $ft^3 \times 10^6$ (Δh, ft)	(11) Total Storage $ft^3 \times 10^6$ (Σh, ft)	(12) Reservoir Elev.	Remarks
66		202000				35,604						
	6		193,000	4169	154.2		36,808	795	3374 (1.27)	26,910 (10.10)	154.10	
72		184000			~~.7~~	37,952						
	6		174,000	3758	155.3		38,920	840	2918 (1.10)	29,828 (11.20)	155.20	
78		164000			~~.8~~	39,888						
	6		155,000	3348	156.1		40,592	876	2472 (0.93)	32,300 (12.13)	156.13	
84		146000			~~.6~~	41,296						Increase to 350 wide
	6		137,000	2959	156.7		42,871	926	2033 (0.76)	34,333 (12.89)	156.89	
90		128000			~~.9~~	44,447						
	6		118,000	2549	157.4		45,121	975	1574 (0.59)	35,907 (13.48)	157.48	
96		108000			~~.5~~	45,795						
	6		99,000	2138	157.9		46,276	999	1139 (0.43)	37,046 (13.91)	157.91	
102		90000			~~.5~~	46,757						
	6		81,000	1749	158.2		47,046	1016	730 (0.27)	37,776 (14.18)	158.18	
108		72000			~~.1~~	47,335						
	6		62,000	1339	158.3		47,431	1024	315 (0.12)	38,091 (14.30)	158.30	
114		52000			.1	47,527						
	6		50,000	1080	158.4		47,623	1028	52 0.02	38093 (14.32)	$\boxed{158.32}$	
$\boxed{120}$		48000				$\boxed{47,720}$						
	6		46,000	993								
126		44000										
	6		42,000	907								
132		40000										

Maximum Q = 47,720 cfs

Say 158.3
− 144.0
Added 14.3
Stage 13.0
27.3
Max. Stage.

C-7/15

Crest @ Notch at 120 hrs into flood @ 27.3 stage = elev. 158.3

① Time	② Δt hrs	③ I cfs Add Base Flow 20,000	④ Avg. I cfs	⑤ I Volume $ft^3 \times 10^6$	⑥ Trial Elev.	⑦ O cfs	⑧ Avg. O cfs	⑨ O Volume $ft^3 \times 10^6$	⑩ ΔS $ft^3 \times 10^6$ (Δh, ft)	⑪ Total Storage $ft^3 \times 10^6$ (Σh, ft)	⑫ Reserv. Elev. 131.0
0		32000				20,000					144.0
	6		35,000	756	144.1		20,100	434	322 (0.12)	322 (0.12)	
6		38000			~~.2~~	20,200					144.12
	6		45,500	983	144.3		20,400	440	543 (0.20)	856 (0.32)	
12		53000			~~.3~~	20600					144.32
	6		60,500	1307	144.6		20,800	450	857 (0.32)	1713 (0.64)	
18		68000			~~0.5~~	21000					144.64
	6		89,000	1922	145.1		21475	464	1458 (0.55)	3171 (1.19)	
24		110000			~~0.7~~	21950					145.19
	6		131,000	2830	146.0		22725	491	2339 (0.88)	5510 (2.07)	
30		152000			~~1.2~~	23500					146.07
	6		173,000	3737	147.2		24565	530	3207 (1.21)	8717 (3.28)	
36		194000			~~1.6~~	25630					147.28
	6		215,000	4644	148.8		27065	584	4060 (1.53)	12777 (4.81)	
42		236000			~~1.8~~	28500					148.81
	6		257000	5551	150.6		30,050	650	4901 (1.84)	17678 (6.65)	
48		278000			~~2.2~~	31,600					150.65
	6		299,000	6458	152.8		33550	725	5733 (2.16)	23411 (8.81)	
54		320000			~~2.3~~	35,500					152.81
	6		320,000	6912	155.1		38,435	830	6082 (2.29)	29493 (11.10)	
60		320000			~~2.2~~	41,370					155.10
	6		306,500	6620	157.3		43485	939	5681 (2.14)	35124 (13.24)	
66		293000			~~1.9~~	45,600					157.24

Remarks

[illegible] $\times 10^6$ ft^3/0.1' Rise Δh

Crest elev.

Stage = 13.0 ft

Section similar to MP 0.7 w/ adjusted elev.

(5.5 fps)

(use 350' wide)

RUSSELL FIORD STORAGE ROUTING
300,000 cfs Peak Storm
Base Flow = 20,000 cfs.

C-8/15

(1) Time	(2) Δt hrs	(3) I cfs	(4) Avg. I cfs	(5) I Volume $ft^3 \times 10^6$	(6) Trial Elev.	(7) O cfs	(8) Avg. O cfs	(9) O Volume $ft^3 \times 10^6$	(10) ΔS $ft^3 \times 10^6$	(11) Total Storage $ft^3 \times 10^6$	(12) Reserv. Elev.	Remarks
66		293000				45,600					157.24	
	6		279500	6037	159.2		47430	1024	5013 (1.88)	40,137 (15.12)		
72		266000			~~1.6~~	49,260					159.12	
	6		251000	5422	160.8		50,755	1096	4326 (1.63)	44463 (16.75)		(6 fps)
78		236000			~~1.4~~	52,250					160.75	
	6		222500	4806	162.2		55,235	1193	3613 (1.36)	48076 (18.11)		
84		209000			1.1	58,220					162.11	(380 ft wide)
	6		195500	4222	163.3		61,110	1320	2902 (1.10)	50,978 (19.21)		
90		182000			.7	64,000					163.21	
	6		167,000	3607	164.0		64,800	1400	2207 (0.83)	53185 (20.04)		
96		152000			0.6	65,600					164.04	
	6		138 500	2992	164.6		66,285	1430	1562 (0.59)	20.63		
102		125000			0.4	66,970					164.63	
	6		111500	2408	165.0		69,420	1500	908 (0.34)	(20.97)		
108		98000			0.1	71,870					164.97	6.5 fps
	6		83000	1793	165.1		72000	1555	238 (0.09)	(21.06)		
114		68000			0	72,117					165.06	509 165.1
	6		65000	1404	165.1		72,117	1557	<153> −0.06	21.00		− 144.0
120		62000				72,117					165.00	Add 21.1
	6		59000	1274								Stage 13.0
126		56000										34.1
	6		53000	1144								Max Stage
132		50000										

Crest c̄ Notch @ 114 hrs into flood @ 34.1 ft stage = elev. 165.1

C-1

6/15

C-10/15

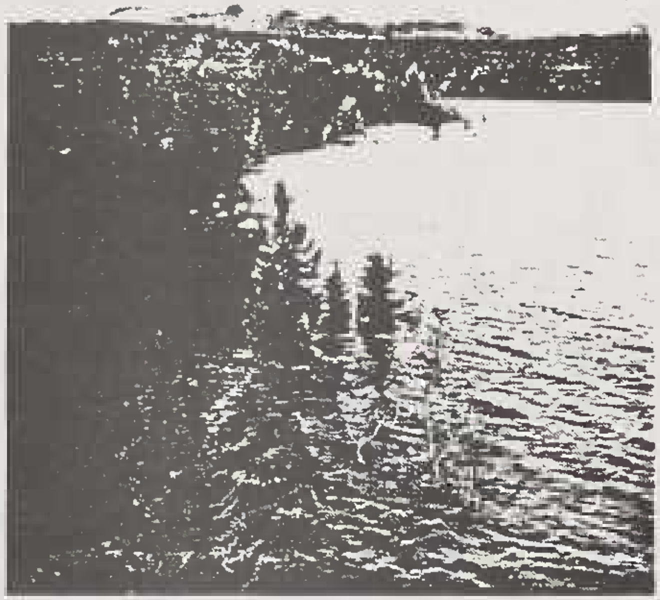


Figure 4. -- "Drowned" trees near southern end of Russell Lake.

Mid July - Mid August
1.02 ft/day
(1.02)(2697) = 27,500 cfs

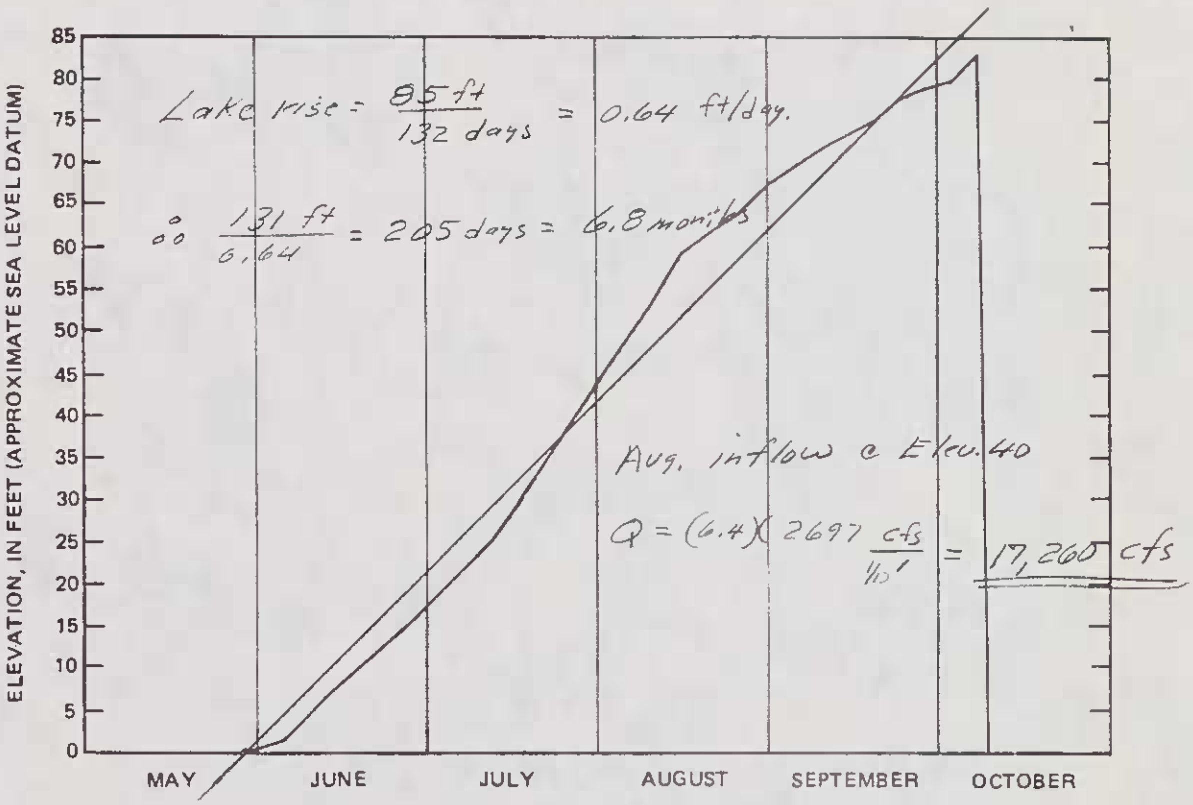


Figure 5. -- Water levels in Russell Lake, summer 1986. Graph drawn from water levels measured near south end of lake (U.S. Geological Survey station No. 15129990).

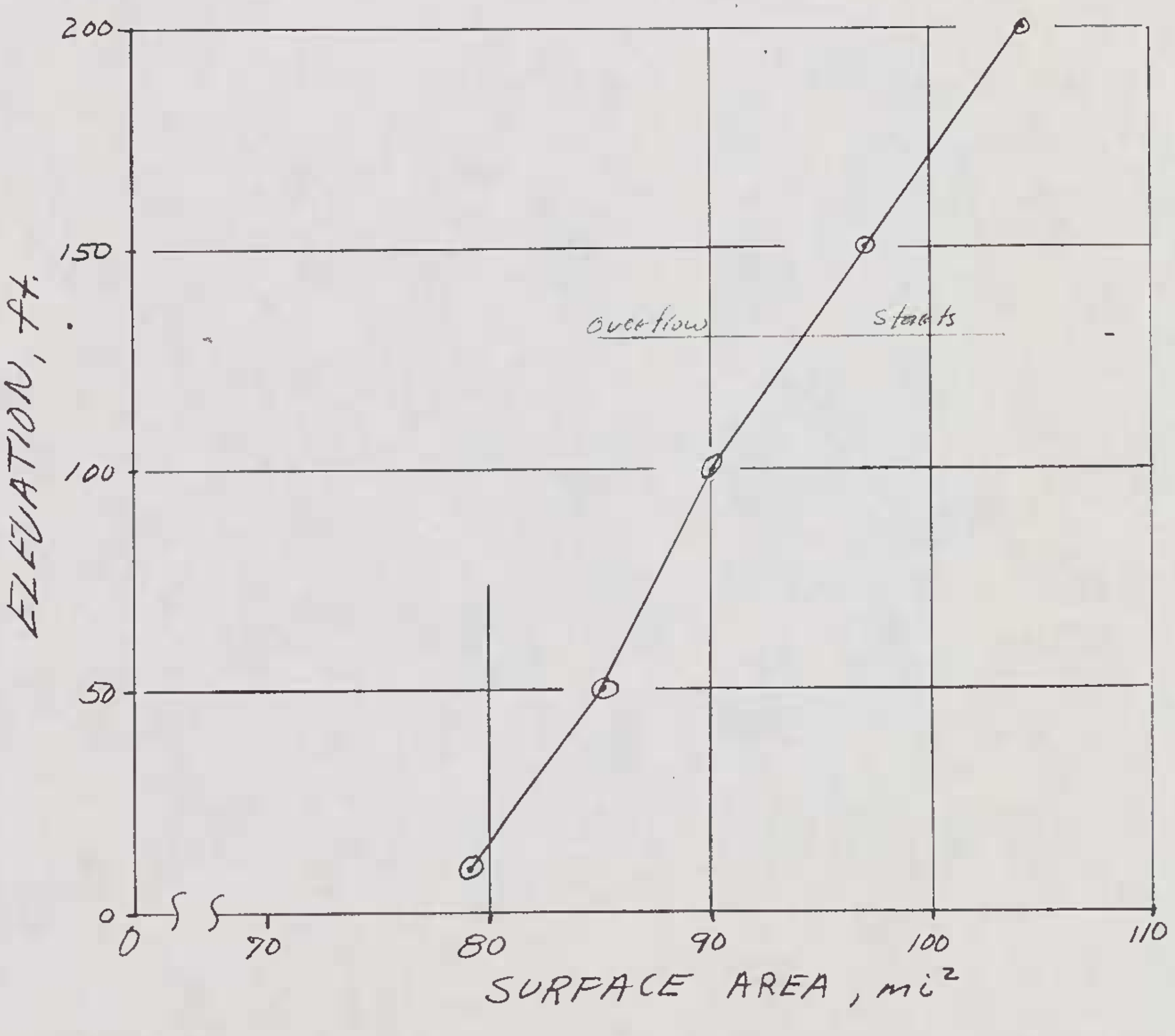
Page 4: From USGS Open File Report 86-545
by Harold Seitz, Don Thomas + Bud Tomlinson

UPDATED

Les Paul
8/21/87

Russell Lake Storage Volumes.

Elev.	Russell Lake mi^2	Nunatak Fiord mi^2	Total mi^2	Acres
10	62.19	16.88	79.07	50,605
50	65.56	20.00	85.56	54,758
100	69.60	20.72	90.32	57,805
150	75.14	22.07	97.21	62,214
200	80.47	23.72	104.19	66,682



RUSSELL LAKE INFLOW

Elev.	Area mi^2	Area $ft^2 \times 10^6$	Volume Per 0.1 ft $ft^3 \times 10^6$	INFLOW for Lake Level Rise of 0.1 ft per day cfs	INFLOW for Lake Level Rise of 1 inch per day cfs
10	79.0	2,202.4	220.24	2549	2124
20	80.6	2,247.0	224.70	2601	2167
30	82.0	2,286.0	228.60	2646	2205
40	83.6	2,330.6	233.06	2697	2248
50	85.6	2,386.4	238.64	2762	2302
60	86.0	2,397.5	239.75	2775	2313
70	87.0	2,425.4	242.54	2807	2339
80	88.0	2,453.3	245.33	2839	2366
90	89.0	2,481.1	248.11	2872	2393
100	90.0	2,509.0	250.90	2904	2420
110	91.5	2,550.9	255.09	2953	2461
120	93.0	2,592.7	259.27	3001	2501
130	94.5	2,634.5	263.45	3049	2541
140	95.6	2,665.2	$\boxed{266.52}$	3085	2571
150	97.2	2,709.8	270.98	3136	2613

Example:

Inflow for Lake level rise of 13"/day @ el. 90 = (13)(2393) = 31,109 cfs

L. Paul
10/2/87

Dangerous River "n" value

Field measurements by Paustin and others.

Q = 10,800 cfs
Velocity = 5 fps
Area = 2050 ft^2
WP = 380 ft.

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

Slope from Quad map = 0.0012

$$\therefore \quad n = \frac{1.49}{5} \left(\frac{2050}{380}\right)^{2/3} (0.0012)^{1/2}$$

$n = 0.032$

@ S = 0.0014
n = 0.034

@ S = 0.0016
n = 0.037

$\therefore$ Will assume "n" $\approx$ 0.033 for channel similar to Dangerous River at Bridge.

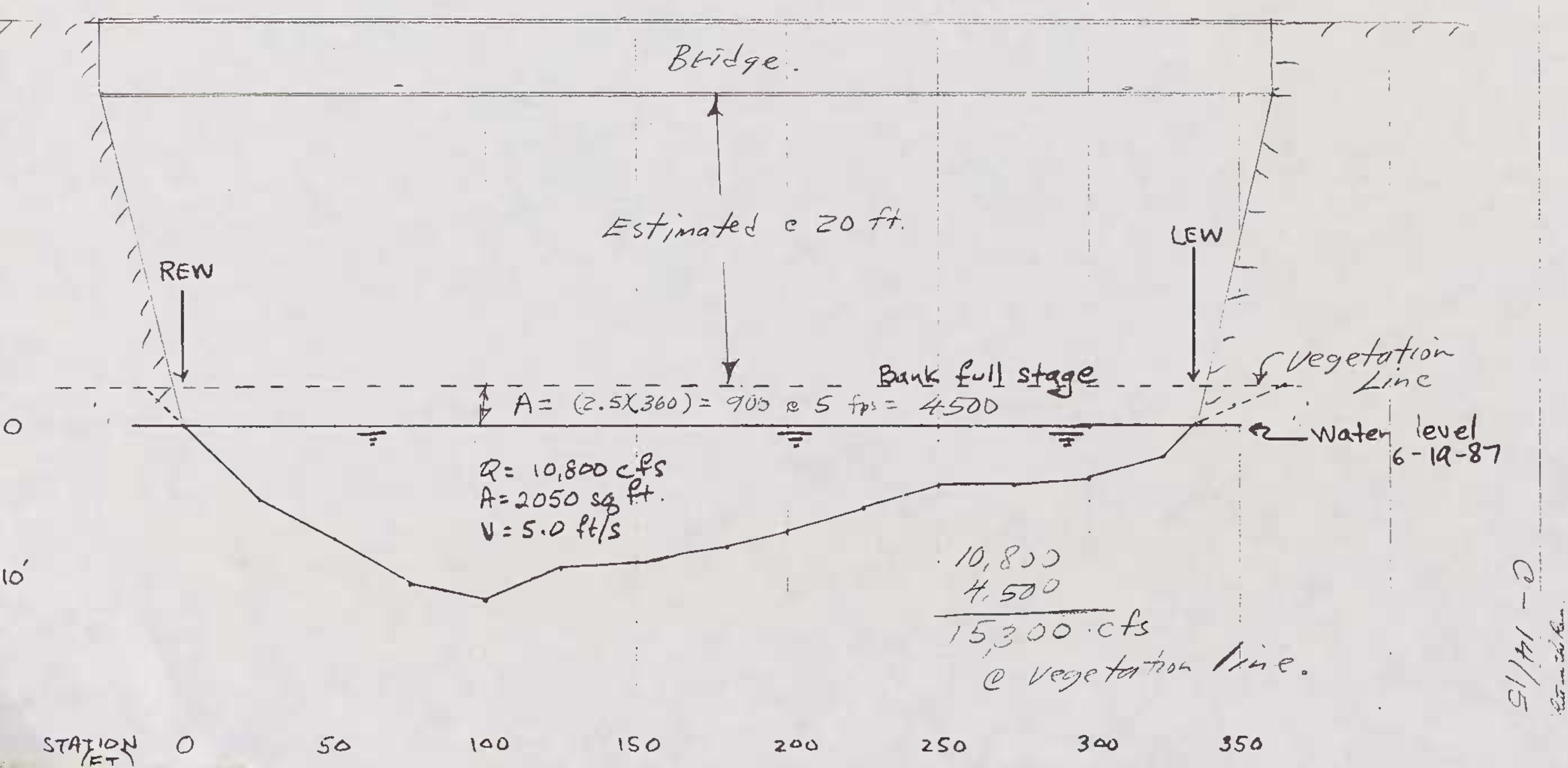
Other assumptions:
Notch area of Old Sitkik w/trees $\approx$ 0.13
(From FHWA-TS-84-204 pg. 32)

DANGEROUS RIVER

6-19-87 moc

NEAR YAKUTAT, AK

$S \approx 0.0012$ from [illegible] map.



PUBLICATION DATE: 10/31/84

ALASKA 945 3220

YAKUTAT, YAKUTAT BAY

Tidal datums at Yakutat, Yakutat Bay are based on the following:

LENGTH OF SERIES	=	17 YEARS
TIME PERIOD	=	1966-1972, 1974-1983
TIDAL EPOCH	=	1960-1978
CONTROL TIDE STATION	=	SITKA (945 1600)

Elevations of tidal datums referred to mean lower low water (MLLW) are as follows:

HIGHEST OBSERVED WATER LEVEL (3/28/64)	=	15.69 FEET
MEAN HIGHER HIGH WATER (MHHW)	=	10.04 FEET
MEAN HIGH WATER (MHW)	=	9.20 FEET
MEAN TIDE LEVEL (MTL)	=	5.29 FEET
MEAN LOW WATER (MLW)	=	1.38 FEET
MEAN LOWER LOW WATER (MLLW)	=	0.00 FEET
LOWEST OBSERVED WATER LEVEL (11/22/76)	=	-4.41 FEET

Bench mark elevation information:

	ELEVATION IN FEET ABOVE:		
BENCH MARK STAMPING	MLLW	MTL	MHW
3220 J 1977	21.80	16.51	12.60
3220 K 1977	25.43	20.14	16.23
3220 L 1977	52.72	47.43	43.52
3220 M 1977	76.98	71.69	67.78
3220 P 1977	22.10	16.81	12.90
3220 Q 1977	85.72	80.43	76.52
3220 R 1977	85.73	80.44	76.53
3220 S 1977	68.92	63.63	59.72
3220 T 1977	87.06	81.77	77.86
3220 U 1977	14.61	9.32	5.41

3.28 ft/meter

APPENDIX A

COPY FOR
Paul

1/15

United States Department of Agriculture | Forest Service | Region 10

Reply to: 7500

Date: SEP 23 1986

Subject: Yakatut Field Visit to Evaluate Outflow Alternatives

To: Forest Supervisor, Chatham Area

Two copies of the report for the subject field visit are enclosed.

James A Wolfe
JAMES A. WOLFE
Director of Engineering
and Aviation Management

Enclosure (2)

cc:
LMW, 1 report
J.Wolfe, 1 report
L.Paul, 1 report

091886 1345 eam 7500 lp

4/15

YAKUTAT FIELD VISIT TO EVALUATE RUSSELL LAKE EXIT ALTERNATIVES

Les Paul, Regional Hydraulic Engineer
Bill Powell, Regional Geotechnical Engineer
Dennis Rogers, Chatham Area Engineering Geologist

August 19-20, 1986

PURPOSE

The visit was intended to (1) perform a preliminary ground reconnaissance to determine surface materials where Russell lake would overflow and (2) an aerial observation of the lake closure at Gilbert Point.

FINDINGS

GEOTECHNICAL

-The Alsek road South of Russell lake has several borrow pits used for road construction. These pits are about 10-15 feet deep and all contain "glacial outwash materials." Previous materials testing has classified the material as a sandy gravel (GW). See enclosure A for test results. The materials are normally consolidated and were observed in alluvial deposited layers of finer and courser materials. Permeability in the course layers would be relatively high. Water was observed in some of the borrow pits which indicates that the water table was close to the ground surface. Rock sizes ranged to a maximum of three inches with occasional larger sizes. A one to three foot organic soil layer overlies the alluvial deposits.

-"The Notch" is a well defined river channel about 3,000 feet North of the Alsek road. The ground surface in the notch is armored with gravel, cobbles, and boulders up to six feet in diameter indicating that substantial river flows have occurred in the past (see photos 1 & 2). A test hole was dug on the East bank to a depth of two feet. Material was gravels, cobbles, and boulders up to one foot diameter with a silty sand matrix. The material is compact, probably from the weight of past glaciers. Large boulders, up to four feet were observed on the ground surface adjacent to the notch. Materials in this area appear to be much less permeable than the outwash gravels and also less erodible. By air photo interpretation this material probably extends around the South end on the lake and can be distinguished by the existence of many small surface ponds.

-We visited the lower Situk via the Lost River Road. Materials in this area were generally fine sands and silts which appear to be past beach deposits.

-We were asked to evaluate the feasibility of using explosives and/or heavy equipment to open a channel from Russell Lake to Disenchantment Bay. Based on a fixed wing reconnaissance, measurements from photographs taken during this flight, and a short conversation with Larry Mayo, the following information was obtained:

1. Most of the moraine is in contact with a steep rock slope at Gilbert Point. This would make it difficult to develop road access from Disenchantment Bay.

3/15

2. The length of the moraine contact at Gilbert Point on August 20, 1986 was about 1,500 feet. The moraine varies from near 0 to about 100 feet wide (see photo 3).

3. Materials are compacted marine sediments with various size rock fragments deposited by the glacier. The ice appears to be higher than the moraine and forms a rough uneven surface with many crevices.

4. Larry Mayo has taken 3 elevation measurements since the closure occurred on May 29, 1986. Over the entire period from May 29 to August 31 the average rise has been one foot per day. Larry felt that the rate of rise will continue to be enough to prevent overtopping by Russell Lake. There is the possibility of a breach occurring by rapid calving of the glacier in deep water, especially if a significant earthquake occurred.

-We visited the Dangerous River bridge to evaluate typical bank stability. The channel banks were naturally armored with 6 to 12 inch rounded rock on the surface (see photos 4 & 5). We were not able to determine the boulder sizes in the channel, but assumed they are larger rock sizes.

This was a reconnaissance trip with limited time. We did not map the distribution of materials. Detailed studies would be needed to obtain information for engineering analysis.

HYDRAULIC

-The existing Situk river has the following calculated flows:

Mean Annual = 640 cfs
Q10 = 8,000 cfs
7Q10 LOW = 80 cfs

-A cross section of the notch is shown on enclosure C. The bank full flow (most recent channel) of 34,000 cfs would produce a velocity of 15 fps which compares favorably with the erosive limits of the two foot diameter material armoring the channel. The "notch" slopes upward at 60% to the East and 20% to the West to a total depth of 50 ft. Flows greater than 34,000 cfs will be contained within the "notch", however if ice or debris jams plug the channel to a depth of 33 feet, then outflow would begin thru the Main Situk lake drainage.

velocities have been revised downward 3/88 LP

The vegetation growth in the notch is shown on photo 6. This material, if not removed, would produce an initial "n" value of 0.2. As flow increases, erosion would scour the trees from this channel, returning the "n" value to 0.05. Altimeters indicated that the notch was approx. 50 ft lower than mile post 13.5 on the Alsek road.

-The Old Situk meander patterns shown on aerial photos were confirmed on the ground. The Meander limits at the Old Situk crossing on the Alsek road is approximately 1300 ft. Relative relief at this site is approx. 15 ft. from stream bottom to the adjacent crests of the Alsek road (see photo 7).

-We do not have any calculations for a design hydrograph from Russell lake. The current lake increases, on a daily basis, have been converted to cfs and are shown on enclosure B. We think a Q100 design flow may approach 50,000 cfs. The Old Situk meander plains would contain this flow providing it did not have a ice or debris plug that forced it out of it's channel.

-The lost river road trip verified a definable rise west from the Lost river, indicating that the western meander limits of the main Situk is just west of the lost river bridge. We believe the western boundary shown on the enclosed map is generally accurate. The eastern boundary, however, is not well defined.

-State of Alaska, Dean Griggs, provided information that the Dangerous River bridge on the Alsek road shown in photo 4 was designed for a Q50 of 31,500 cfs.

CONCLUSIONS

1. Because of safety problems and the rate of glacier advancement, it does not appear feasible to open a channel to drain Russell Lake using conventional methods of excavation. It might be possible to use huge volumes of explosives, detonated on the surface of the ice, but it would be difficult to predict if this would be effective and the costs would be prohibitive.

2. Materials in the "notch" will erode at a slow rate and any meandering would take a relatively long time. The materials in the outwash will erode similar to the Dangerous River banks and meandering will occur on a continual basis. The map (enclosure D) indicates the general location of compact till and outwash materials.

3. The Old Situk River channel and meander terraces will contain the lake overflow until it reaches the main Situk flood plain. The 5 culverts on the Alsek road that presently pass the Old Situk flow will be washed out by the lake overflow. We cannot predict what will occur as the existing timber in the "notch" and Old Situk channel is washed away to form debris dams and/or diversions from the existing channel. Also if overtopping occurs with large quantities of ice/woody debris in the South end of the fiord, the potential for temporarily blocking narrower portions of this channel is probably high or at least significant.

4. The main Situk flood plain cannot be accurately defined using existing contour maps. We assume the lake overflow will be contained in a 1000 foot wide channel(s) located within the area shown in red on photo 8. A better definition will soon be avaliable following ongoing ground control and photo interpretation. A new contour map will not be produced until spring of 1987.

ALTERNATIVES

1. Do Nothing. Photo 8 indicates our estimate of flood plain limits caused by the lake overflow. Alsek road will be closed at mile post 11.

2. Construct dam on the Old Situk just downstream from the Alsek road crossing and divert lake overflow into canal as shown on photo 9. This alternative has a preliminary cost estimate of $48,300,000. We do not know what changes would occur at the stream-ocean interface or the long term stability of the canal as the lake overflow initiates its meander patterns.

3. Construct a canal thru the moraine as shown on photo 10. Allow the lake overflow to seek its own course to the ocean, probably within an area shown by the dotted lines but at an unknown location. The preliminary cost estimate for this canal is $46,000,000. Exploratory drilling is needed for this alternative to determine if solid rock will be encountered during excavation activities.

3A. Construct additional canal to control the location of lake overflow from the canal in alternative 3 to the ocean. Photo 10 includes this alternative. The preliminary cost estimate for this added canal is $42,600,000.

RECOMMENDATIONS

1. A photogrammetrically prepared topographic map needs to be prepared for the compact till area east and south of the "notch" (5 miles x 2 miles) similar to the map USGS prepared for the area north from the "notch" to the Situk lake entrance. This modest investment is needed to determine additional alternate routes should a decision be made to proceed with construction of a canal.

2. As a minimum the vegetation in the Old Situk must be cut flush and removed. Without this effort, debris may plug and alter the existing channel course before it enters the main Situk.

3. If a decision is made to construct an outlet for the overflow, detailed surveys, soils investigations, contract preparation and contractor selection would have to "fast track" in order to complete construction prior to overtopping.

4. A prediction of the inflow hydrograph from USGS is needed to estimate when the overflow will start.

Les Paul   for Bill Powell   for Dennis Rogers

Enclosures and Photos

082986 1059 eam 7500 lp

Photo 1. Typical armor rock with 2 ft diameter as minimum stable material. Lower end of "Notch."

Photo 2. A few typical 6 ft. diameter boulders in mid and upper end of "Notch."

Photo 3 8/20/86 7/15
Closure @ Gilbert Point
Approx. Scale 1" = 375 ft.

Photo 4. Dangerous river bridge looking U/S.

Photo 5. Dangerous river looking D/S from photo point 4.

Photo 6. Typical vegetative growth located in mid-point of "Notch."

Photo 7. Old Situk meanders show in timber area from photo center towards upper left of photo.

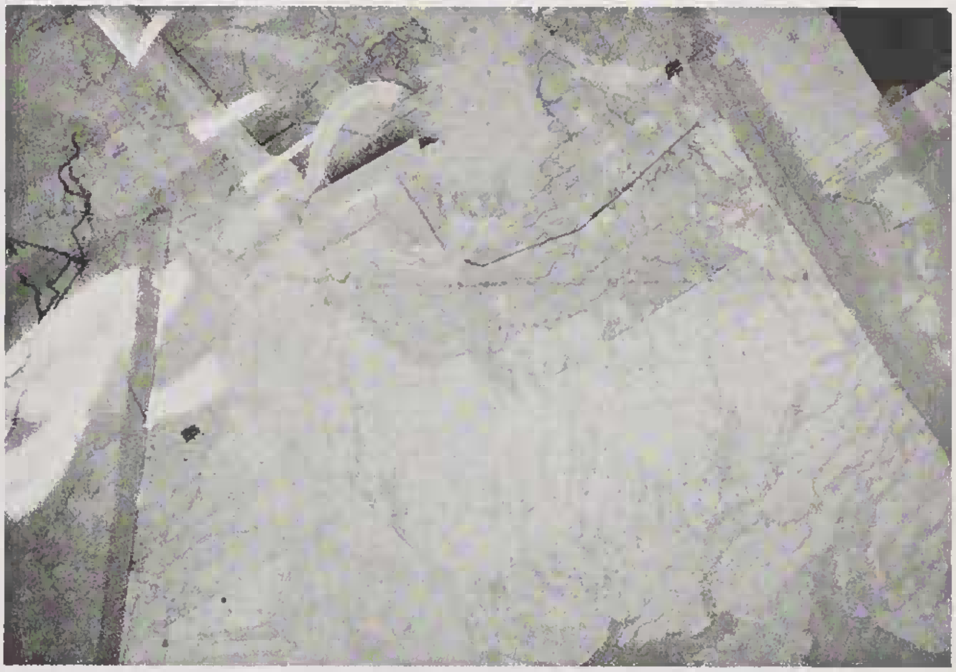


Photo 8. Red area is preliminary estimate of meander limits for overflow. (Disregard tape and overlays around edges.)

Photo 9. Alternative 2 shown in red.

(Disregard tape and overlays around edges.)

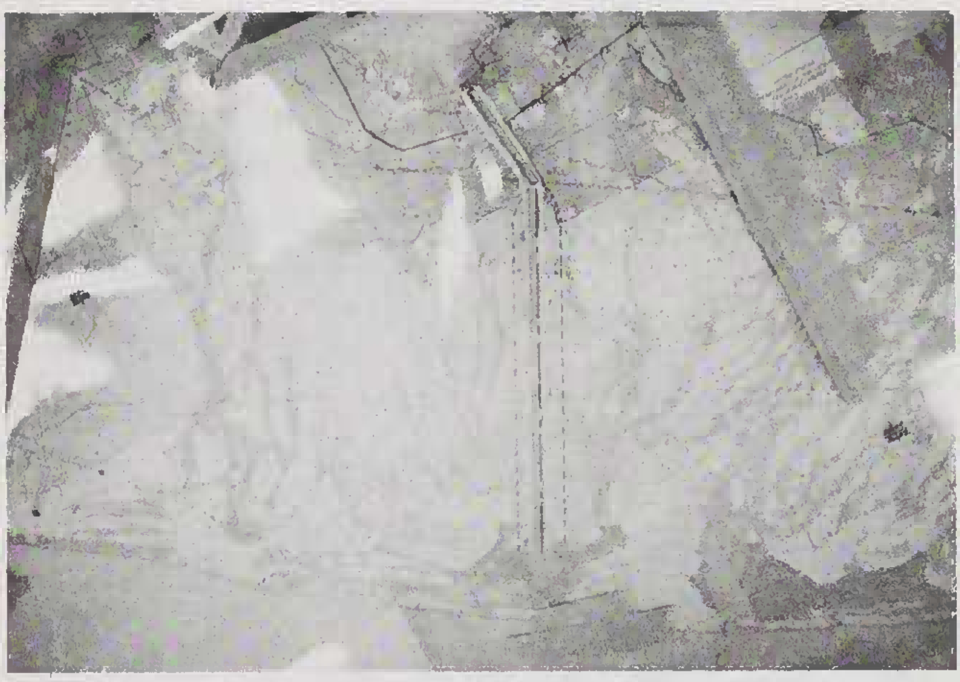


Photo 10. Alternatives 3 and 3A.
3A is red canal between dashed lines.
(Disregard tape and overlays around edges)

WILLAMETTE NATIONAL FOREST

REPORT OF LABORATORY

Enclosure A 12/15

SAMPLE FROM: ... Cr	DEPTH	LOCATION: M.P. ___ T. 27 S., R. 36 E., S	
SAMPLED BY: Ron Lange	TITLE	DATE SAMPLED	REPORT TO: Rogers — SENT ✓
TYPE OF MATERIAL: gravel Sand		APPLICABLE SPEC.	ADDRESS: Sitka ALASKA
DESCRIPTION OF MATERIAL			

SAMPLE NO. 0 — Yak II — LAB NUMBER 7-85-32 — SCHEDULE DATE

X	LIQUID LIMIT (AASHTO T89)	NP
X	PLASTICITY INDEX (AASHTO T90)	NP
X	MOISTURE-DENSITY TEST (AASHTO T99 METHOD D) MAXIMUM DRY DENSITY, PCF	133.2
X	OPTIMUM MOISTURE, %	3.3%
X	CLASSIFICATION: AASHTO M145	A-1-a (0)
X	UNIFIED	GW
	CALIFORNIA BEARING RATIO (AASHTO T193) 95%	16.0
	90%	4.2
	85%	
	SAND EQUIVALENT (AASHTO T176) NATURAL	
	MANUFAC	
	LOS ANGELES ABRASION (AASHTO T96 GRADING ___)	
	DURABILITY (AASHTO T210) COARSE / FINE	
	ORE. AIR DEGRADATION H / P20	
X	SPECIFIC GRAVITY (AASHTO T 100)	2.74

SIEVE ANALYSIS (AASHTO T ___)

SIEVE SIZE	% PASSING TEST	% PASSING SPEC.
3"	100	
2 1/2	96	
2	92	
1 1/2	88	
1	80	
3/4	73	
1/2	63	
3/8	57	
No 4	40	
10	23	
40	6	
100	3	
200	2.1	

REMARKS: Moisture Content at time of Penetration = 4.1

SIGNED: Don Smith — DON SMITH   DATE: 8-8-[illegible]

TITLE: MAT'LS ENG. TECH.

Enclosure B

7/28/86

Russell Lake.

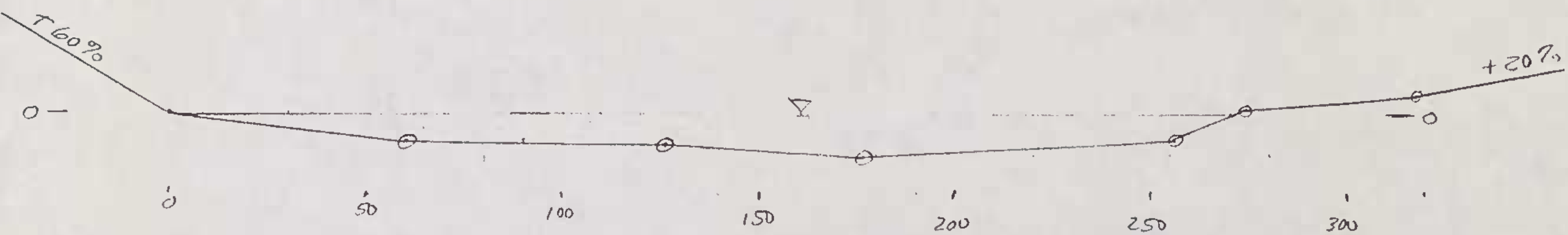
Area = 76 sq. miles = 2,118,758,400 ft^2

Rise/day ft.	Storage/day cu. ft. $\times 10^9$	Inflow cfs	Inflow m^3/sec
0.1	0.211,875,840	2,452	69.4
0.2	0.423,751,680	4,904	138.8
0.3	0.635,627,520	7,356	208.3
0.4	0.847,503,360	9,809	277.8
0.5	1.059,379,200	12,261	347.2
0.6	1.271,255,040	14,714	416.7
0.7	1.483,130,880	17,165	486.1
0.8	1.695,006,720	19,618	555.6
0.9	1.906,882,560	22,070	625.0
1.0	2.118,758400	24,523	694.5
1.1	2.330,634,240	26,975	763.9
1.2	2.542,510,080	29,427	833.4
1.3	2.754,385,920	31,879	902.8
1.4	2.966,261,760	34,331	972.3
1.5	3.178,137,600	36,784	1,041.7
1.6	3.390,013,440	39,236	1,111.2
1.7	3.601,889,280	41,688	1,180.6
1.8	3.813,765,120	44,141	1,250.1
1.9	4.025,640,960	46,593	1,319.5
2.0	4.237,516,800	49,045	1,388.9

Channel Slope @ Upper end ≅ 0.005 (1/200)
@ last 10 miles ≅ 0.0005 (1/2000)

Section thru notch. Looking D/S.

South side	Away. +60% / 0	- 6.6 / 60	-7.9 / 127	-10.4 / 177	-6.5 / 255	1.6 / 273	5.6 / 318	+20% / Away



$$A_0 = \frac{(6.6)(60)}{2} + \left[\left(\frac{6.6+7.9}{2}\right)(67)\right] + \left[\left(\frac{7.9+10.4}{2}\right)(50)\right] + \left[\left(\frac{10.4+6.5}{2}\right)(78)\right] + \frac{6.5(45)}{2}$$

$$A_0 = 198 + 485 + 457 + 659 + 146 = 1945 \text{ ft}^2$$

$$V_0 = \frac{34{,}000}{1945} = 17 \text{ fps.}$$ < 15 fps @ ≈ +1 elev. on section.

$A_{+2} = 1945 + 560 = 2505$ $\quad V_{+2} = 34{,}000/2505 = 13.6$ fps

$A_{+4} = 2505 + 636 = 3141$ $\quad V_{+4} = 34{,}000/3141 = 10.9$ fps.

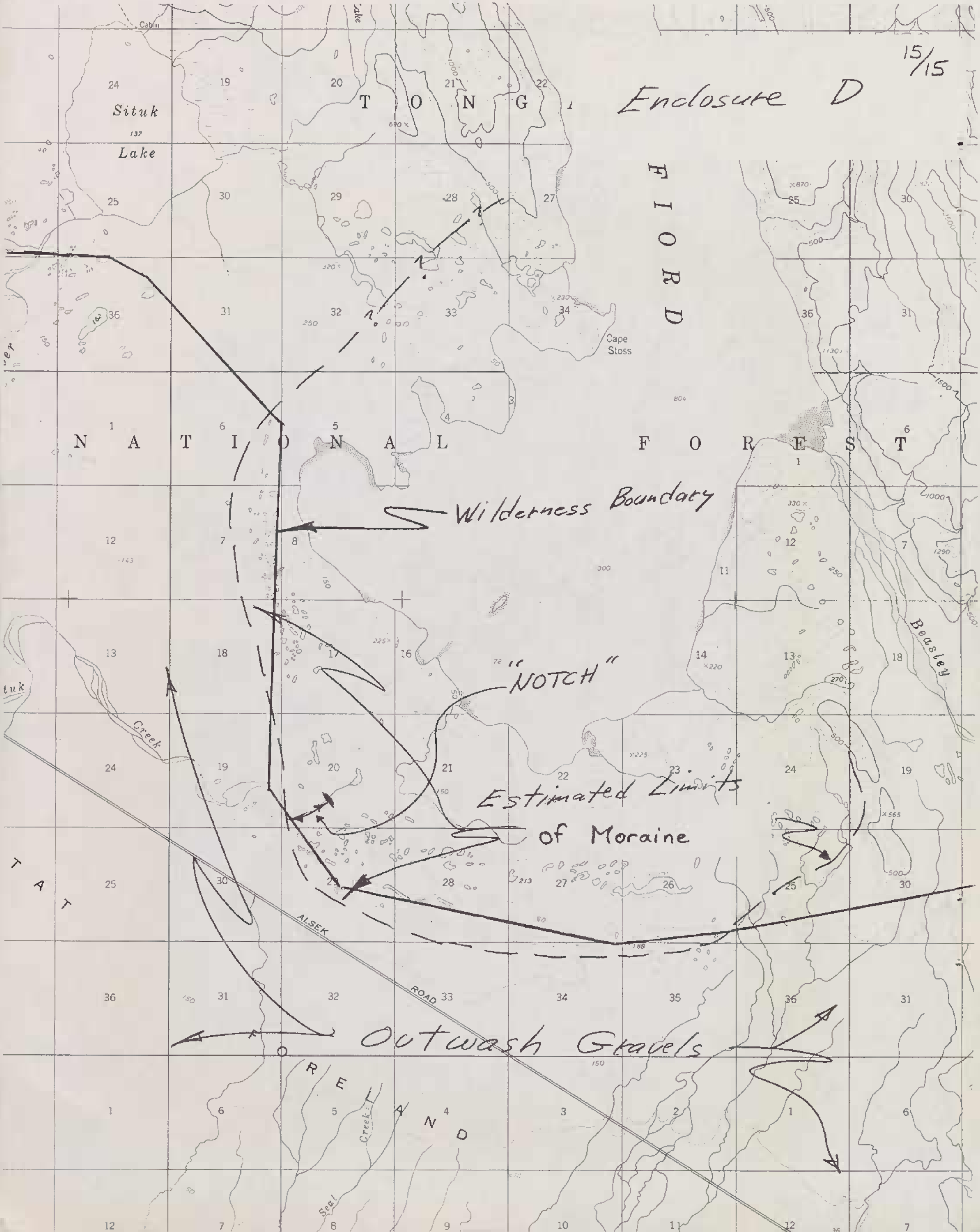
$A_{+6} = 3141 + 660 = 3800$ $\quad V_{+6} = 34{,}000/3800 = 8.9$ fps.

Enclosure C

14/15

15/15

Enclosure D




MAP A
Situk River Flood Plain Analysis
A black and white half-tone print of an uncontrolled color photo mosaic
Photo Date: 9/86
Approximate Scale 1:25,000


MAP B
Situk River Flood Plain Analysis
An overlay of MAP A showing Alaska state plane coordinates and cross-section locations
L. Paul
January, 1988
2,880,000
1,630,000
2,890,000
1,610,000
2,880,000
1,620,000
2,850,000
1,600,000
2,850,000
1,580,000
2,830,000
1,610,000
2,830,000
1,580,000
0.3 mile
0.5
0.9
1.2
4.2
5.2
6.1
7.3
8.4
9.4
10.3 mile
10.9
12.2
13.3
14.2
15.0
16.1
17.0 mile
11A


Russell Fiord
Overflow "Notch" Elevation 131.1 ft
MAP C
Situk River Flood Plain Analysis
An overlay of MAP A showing flood limits for 10,000 cfs and 50,000 cfs overflows from Russell Fiord
L. Paul
January, 1988
LEGEND
10,000 cfs flow
10,000 cfs flows lacking definable boundaries and side channel flow
50,000 cfs flow
50,000 cfs flow lacking definable boundaries
Islands of higher ground within 50,000 cfs flood limits
H
Approximate Scale 1:25,000
Airport Runway Elevation 22.9 ft
Tide Flats
Possible Closure
Ocean Entrance
?